PRINCIPLES AND PRACTICE OF
X-RAY TECHNIC FOR DIAGNOSIS

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FOR DIAGNOSIS

BY

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WITH 61 ILLUSTRATIONS

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PREFACE

The authors' aim in the preparation of this book is to put into the hands of the student and operator a formula on which to base his work in order that he may obtain better results and thus be able to reach a more correct diagnostic interpretation.

The photographic illustrations are original and are here shown in the belief that many men, able to spend but a limited time at a school of instruction or laboratory, may ocularly obtain sufficient knowledge of the proper positions for accurate findings that it may be of material assistance in their work.

The table of exposures herein given are not to be accepted as a fast and fixed rule, but are those, which from experimentation, have given the author the best results.

In preparing this manual it is not the purpose to detail the fundamentals of electricity as applied to roentgenology, nor is it the intention to take up the question of diagnosis: these can be obtained readily and more fully from works written upon these subjects.

The author desires here to acknowledge the valuable aid rendered him by his laboratory assistants and others, and also his appreciation of the publishers for the typographic and pictorial excellence of this book.

JOHN A. METZGER, M.D.

Los Angeles, California.

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GLOSSARY AND INDEX OF ELECTROMEDICAL TERMS

Ampere.—The unit of current strength or the current carried in one second, by the force of one volt, through a circuit where the resistance is one ohm.

Anode.—The positive pole.

Anode Rays.—The rays from the positive end of a vacuum tube.

Atom.—An ultimate indivisible particle of matter.

Break.—An opening in the circuit.

Cathode.—The negative pole.

Cathode Rays.—The rays from the negative end of a vacuum tube.

Circuit.—The path traversed by the current.

Coil Induction.—Rolls of wire in which the current is induced by the alternate opening and closing of a circuit.

Commutator.—A device for changing the direction of the current.

Cone.—Funnel or cylinder shaped lead lined attachment to tube stand for limiting field of rays' activity.

Constant Current.—Galvanic current from a constant source.

Crooke's Tube.—One type of tube for generating x-ray.

Current Controller.—A device or rheostat for controlling current.

Current Strength.—Ampèrage. Current strength equals pressure divided by resistance.

Dead Wire.—One that is not conducting electricity.

Dyne.—The unit of force.

Electric Moxa.—Burn made on the skin by electricity.

Electromotive Force.—E. M. F. The voltage or pressure of current strength, E equals C x R, pressure equals current strength multiplied by resistance.

Erg.—The unit of work.

Fluorescence.—The greenish yellow color on the surface of an excited x-ray tube.

Fluoroscope.—A fluorescent screen for x-ray examinations.

Ground Circuit.—Connecting one pole to the floor, water or gas pipe by means of wire, chain or cord.

Hard Tube.—An x-ray tube having a high vacuum.

Insulators.—Substance which hinders the passage of electricity.

Interrupted Current.—One that is alternately opened and closed.

Ions.—Elements into which substance is divided by electrolysis.

Live Wire.—One that is charged with electricity.

Milliampère.—The unit of medical electricity. The one thousandth part of an ampère.

Milliampère Meter.—A meter for measuring electricity in milliampères.

Ohm.—The unit of resistance. Resistance equals pressure divided by current strength.

Positive Pole.—The anode.

Roentgen Ray.—A ray discovered and described by Wilhelm Conrad Roentgen.

Roentgenology.—The study and practice of the roentgen ray as applied to medical science.

Roentgenologist.—One skilled in roentgenology.

Roentgenogram.—A shadow picture produced by the roentgen ray on a sensitive plate or film.

Roentgenograph—(verb).—To make a roentgenogram.

Roentgenography.—Art of making roentgenograms.

Roentgen Diagnosis.—A diagnosis made by means of the Roentgen ray.

Radiability.—Property of an object to transmit Roentgen ray.

Radioparent.—Offering no obstruction to the ray.

Radiolucent.—Offering slight resistance to the ray.

Radiopaque.—Impervious to the Roentgen ray.

Radiograph.—X-Ray picture.

Radiostereoscopy.—The inspection of the interior organs by means of the x-ray.

Radiometer.—An apparatus for measuring the penetrating power of the x-ray.

Radiodermatitis.—Dermatitis caused by exposure to the x-ray.

Radioscopy.—Same as skiascopy.

Resistance.—Is the quality of a conductor which impedes the action of the current. Resistance equals pressure divided by current strength.

Rheochord.—Rheostat, or a metallic wire introduced into the circuit to vary the strength of current.

Rheostat.—An instrument for bringing a definite amount of resistance into the circuit.

Rheotome.—Current breaker. Interrupter.

Ruhmkorff.—A powerful induction coil invented by Ruhmkorff.

Skiagraph.—Same as a radiograph.

Shadowgraph.—Same as a radiograph.

Soft Tube.—An x-ray tube having low vacuum.

Target.—As used, refers to the anticathode of tube.

Tension.—The tendency of electricity to overcome resistance.

Tesla Coil.—A very powerful high tension compound induction coil invented by Tesla.

Transformer.—A step down induction coil. As here used, refers to apparatus, and consists of three essential parts: the motor converter, the high-tension transformer, and the high-tension rectifier or commutator.

Tube Holder.—Stand and clamp for holding x-ray tube.

Unit of Current.—An ampère.

Unit of Force.—One volt.

Unit of Resistance.—The ohm.

Vacuum Tubes.—X-ray tube.

Volt.—Unit of electromotive force.

Voltmeter.—An apparatus for measuring voltage.

Watt.—The unit of work done by one ampère of current when forced by one volt of pressure.

X-ray.—Rays of unknown quantity discovered by Roentgen in 1896.

X-Ray Burn.—A dermatitis caused by a too long, too close or too soft rays from an x-ray tube.

X-ray Pictures.—Radiographs, shadowgraphs, skiagraphs, etc.

PRINCIPLES AND PRACTICE OF X-RAY TECHNIC FOR DIAGNOSIS

CHAPTER I

THE LABORATORY AND APPLIANCES

It is the individual primarily and not the equipment that produces results. Yet in order that the operator may work to advantage he must surround himself with the best he can command and must only expect such results as are compensatory with his equipment. The man with a small, incomplete equipment must not expect or attempt that which is only to be produced by the laboratory with its powerful and scientifically accurate apparatus, any more than the old flintlock of our forefathers is to be put into competition with the modern high-powered rifle. It cannot be done and will only result in failure and possible harm.

A physician should equip his laboratory as best he can and work within its limits; he should follow a given technic; and the results will be fully satisfactory to both physician and the subject. It is well to remember that the ray is just as potent as ever, but that it is now to a great extent, under our control with the result that the public's prejudices are gradually disappearing and better work is being done.

Of use at the present time as generators are the high-frequency machines, the induction coils, and the so-called interrupterless transformers. Of the three the last is the most modern and best. In it one has a power-

ful generating agent and one free from inverse. Yet the induction coil, for certain purposes, will suffice, and the high-frequency portables will furnish fair results if used for plate work within their limits and for emergencies.

As to the tubes in use at the present time, we have the ordinary gas tube, the hydrogen gas tube, and the Coolidge tube.

Gas tubes are used almost exclusively with the induction and high-frequency generators, while in addition to these for use with the transformer, is the Coolidge tube.

The quality and character of the tube for certain specific purposes is all important for success in radiographic work. If the tube selected is either unstable or of a wrong vacuum, it is impossible to get a good result. Again, tubes, similar to all delicately constructed pieces, must be most carefully handled, especially so when new and in the period of seasoning, and not overworked. It has been found that to rest up tubes, even the most recent production, will well repay one in results and in the life of the tube.

The difference between the tubes used with the high-frequency machines and the induction coil is one of the vacuum, and the additional cathode of the former to care for the inverse, while the difference between those for the induction coil and the transformer is that of a heavier target construction and lower vacuum of the one to care for the additional voltage and absence of an inverse.

The Coolidge tube is, however, constructed on an entirely foreign plan. The cathode is a tungsten filament, spiral in shape and surrounded by a sleeve of molybdenum to focus the cathode stream which is heated by a current of electricity either from a storage battery or a specially designed transformer in use with the alter-

nating current. The tube is so constructed as to stand pumping to a vacuum of at least one thousand times higher than the ordinary gas tube, and this vacuum is supposed to remain constant. It is the discharge of electrons of a negative character which projected onto the anticathode regulated by the tungsten spiral that limits the penetration.

The technic varies in the method of operating the tube and must be worked out by the individual operator in accordance with the apparatus used and the source of the filament control. The following essentials of construction, however, must be remembered. The greater the filament heat the greater the discharge, and the higher the voltage backup by the tube the greater the penetration.

Up to a certain point (5 to 10 ma.) the Coolidge tube is self-rectifying and may be operated direct from any suitable transformer, but when the temperature of the focal point reaches such a degree, appreciable numbers of electrons are thrown off, and it is then necessary to use some sort of a control.

When operating from a heavy coil, it is well to include a valve tube to control the inverse which results from the heating of the focal spot and thereby throws additional strain on the glass.

Unlike the Coolidge tube, it becomes necessary, when using the gas tube, for one to have a series which, after a careful seasoning, is so regulated as to give approximately certain degrees of penetration and as far as possible allowed to remain as such. This can readily be accomplished if care has been exercised in the coaching and if the tubes used are for plate work; in this respect the gas tube is far superior as it permits of less secondary radiation with its consequent fog. The principle governing the regulation of the vacuum of gas tubes is one of osmosis controlled by a specially blown and chemi-

cally filled chamber attached to the tube and to which is affixed a metal attachment for shunt.

As the proper exposure depends upon the thickness of the part and the character of the tube, it is essential in order to obtain correct results that one accept some table of exposure—the result of experiments and established weight or thickness, and modify this in inverse proportion to the square of the distance from the plate; namely, three seconds for 10 inches would be 6.7 seconds for 15 inches; twelve seconds for 20 inches; eighteen seconds for 25 inches, and twenty-seven seconds for 30 inches; or if expressed in milliampère seconds, it would be:

Distance:	10....14.1....20....24.5....26.4....30 cm.
Exposure:	10....20....40....60....70....90 ma.

As the penetrating power of the x-ray is dependent on the speed of the cathode stream of the gas tube and the negative character of the electrons projected against the anticathode heated to a selected degree in the Coolidge tube, the latter is varied by increasing or diminishing the potential at the terminals; consequently the necessity of an ammeter in the battery circuit and a milliammeter in the secondary circuit. By carefully making use of these two means of measurement a more or less constant type of the ray can be produced and the necessity is eliminated of a more elaborate and tedious method with the various types of radiometers.

The ingenious method used for the control of the Coolidge tube is at present the most perfect one for controlling the ray as given off from the tube, and is therefore of inestimable value for screening.

When, however, radiometers are desired the following scale of comparative values is here given for use:

Bauer	1	2	3	4	5	6	7	8	9	10
Wehlnelt	1.5	3	4	5	6	7.5	8	9	10.5	
Walter	1	1.2	3	4	5.6		7.8			
Benoist	1	2	3	4	5	6	7	8	9	10
		(Soft)			(Medium)				(Hard)	

The question of working out a table of exposure is open to many defects. Attempts have been made to aid the inexperienced operators to reasonable success, but experience has taught us that adherence to any set table will not bring results. The time of exposure is not solely one worked out along the lines of the law of absorption.

There are three principal means of reaching a proper time regulation:

1. The inverse square law method.
2. The current time relation.
3. Voltage time relation.

Distance Time Relation

The x-ray in traveling out in straight lines spreads over an increasing base as we withdraw the tube from the plate. Consequently, more radiation is intercepted the closer to its source. Move the plate to double the distance and the radiation is but one-fourth as great, etc. Now in order to obtain the same result in radiation, the time must be increased just four times or the same given ratio, according to distance removed, other factors remaining constant.

$$\frac{\text{Time}}{\text{Distance}} = \text{tube current and voltage}$$

The greater the distance the sharper the picture, but the time is in inverse to the square of the distance.

Current Time Relation

Now as to current time. The x-ray energy increases in direct proportion to the current, provided the voltage is constant and distance fixed. Thus we get the same radiation in half the time when using 40 ma. as when using 20 ma. Example:

5 ma.....1.2 sec.
10 ma.....0.6 sec.
15 ma.....0.4 sec.
30 ma.....0.2 sec.

Voltage Time Relation

As to voltage time relation, the following table is reasonably accurate:

2 inches.....	30 Kv.....	16 sec.
3 inches.....	40 Kv.....	9 sec.
4 inches.....	50 Kv.....	5 sec.
5 inches.....	60 Kv.....	4 sec.

The radiation leaving a given target usually increases in proportion to the square of the voltage, all other factors remaining constant; consequently this means of time regulation is but approximate. The parallel spark gap, therefore, is the best available guide, since the average kilovoltmeter is reliable only on the secondary and not for primary, on account of variation under different loads.

An electrostatic voltmeter is the only reliable meter therefore for time voltage; but as this unfortunately is not ordinarily available it becomes necessary, in most instances, to depend upon spark backup.

Law of Densities

Besides distance, etc., there is the factor of densities due to thickness, and this is in proportion to the specific gravity of the tissues and the simple laws of absorption.

It is, therefore, well to establish a working table on average body thickness and average body weight.

Example:

Weight: 150 pounds.
Thickness:
Ankle: 3 in.
Calf: 5 in.
Knee: 5 in.
Thigh: 7 in.
Hip: 8 in.
Abdomen: 10 in.
Chest: 12 in.
Neck: 5 in.
Head: 6 to 8 in.

The accompanying table is solely for the purpose of supplying a reasonable working guide, and is estimated upon the above weight and thickness of parts. It must, therefore, not be accepted as a hard and fast rule, and must be modified to meet varied conditions and personal deference. After practical experience and after becoming master over the peculiarities of his own outfit, the operator will, unquestionably, establish a working table of exposure which will best meet his own requirements.

PART	MA.	GAP	DIST.	TIME.
Hand	20	4	20	1 sec.
Wrist	20	4	20	1½ sec.
Elbow	20	4	20	3 sec.
Ankle	20	4	20	2 sec.
Knee	20	4	20	4 sec.
Shoulder	20	4	20	4½ sec.
Chest	30	5	26	1½ sec.
Head				
A. P.	35	5	20	6 sec.
Lat.	35	5	20	4 sec.
Spine				
Cerv.	35	5	20	2 sec.
Dorsal	35	5	20	3 sec.
Lumbar	35	5	20	5 sec.
Hip	35	5	20	5 sec.
Pelvis	35	5	20	5 sec.
Kidney	20	4	20	2½ sec.
Teeth	20	4	20	2½ sec.

Dangers of the Ray

Before taking up the question of apparatus and technic as applied to the various parts of the body, it might be well briefly to survey the dangers of the ray and the necessity of precaution with the measures that we have at our command. The danger to the operator is the greater under the demands of the present day, while injudicious use or prolonged and repeated exposures will do unlimited harm to our patient.

A question arises as to just how much radiation a subject can be exposed to without producing harm. In answering this, the following facts must be considered: idiosyncrasy, age, skin distance, spark gap, tube current, nature and thickness of the part and the time of exposure. However, with the present facilities of a movable enclosed tube and shutter and foot switch, the examination can be prolonged, and, with the addition of intensifying screens, radiographs taken with safety.

In brief the effect of the x-ray is as follows:

Double the milliamperage,	double the effect.
Double the voltage,	quadruple the effect.
Half the distance,	quadruple the effect.
Double the time,	double the effect.

For radiography on the 30 ma. 5 in. gap and 20 inch target plate distance and aluminum filters up to 3 millimeters, an erythema dose will be produced in about sixty seconds. While for fluoroscopy with the average 2 millimeters of current and skin distance of 12 inches, the same result will be obtained in 10 minutes, with a 4 inch gap 8 minutes; with a 5 inch gap 6 minutes; and with a 6 inch gap 5 minutes. Therefore with chest and gastrointestinal work where screening and plating are both resorted to, care must be used to prevent burns, on account of accumulative action of rays.

In using a small spark gap for plating, although the amount of radiation is less, the exposure required is materially longer, and to get the same plate densely the risk to the skin is relatively greater. This accounts for many cases of dermatitis, and repeated exposures must be therefore limited, but with the knowledge that the number of milliampere minutes allowable varies with the spark gap, and careful consideration as to age, physical condition, etc., of patient, one can use any selected gap with a reasonable amount of safety.

As to the operator, it is well that he limit his exposure as much as possible, as regards extent, time, and distance, interposing, as far as possible, some absorbing material, (lead apron) and make judicious use of the foot switch and shutter. One should study his working conditions as to minimization of time, and under no circumstances use any part of his body for demonstration.

Beside the dangers ever confronting the operator and subject from the rays, there is also the possibility of contact with or discharge from terminals of high tension lines. It is, therefore, wise that one sees to it that all ground wires are intact. Should an unfortunate accident of this kind happen with apparent dire results, one should resort at once to artificial respiration, stimulation, etc.

CHAPTER II

STANDS, TABLES AND TARGET ADJUSTMENT

Either attached or separate tube stands, to be efficient and permit of accuracy, must be of sufficient weight to preclude of any vibration, and, at the same time, must be so flexible as to be adjustable to any angle and with the greatest ease and expediency. A tube stand should be fitted with a lead glass tube shield, diaphragms of from ¾ to 5 inches in diameter, several sizes of cylindrical cones, lead lined, from 3 to 12 inches in diameter with drum attachment or a universal Hickey cone.

A table may be separate or with tube stand attachment, but in every case should be of such length and breadth as to accommodate itself to the various positions and permit of horizontal and vertical posture. It should also be covered with aluminum or celluloid, and carry beneath an enclosed tube for fluoroscopy when possible.

Trochoscopes and combined tables for roentgenoscopic and roentgenographic work are obtained in various designs; these materially facilitate the laboratory work. The one in use in the author's main operating room is of this type, and permits of the employment of two tubes, one on the vertical stand for plate work and the other in the tube box carrier for screening, without the necessity of delay and inconvenience incidental to horizontal and vertical stand and a separate cumbersome tube holder for radiographic work, at the same time permitting of a selection of intermediate angulosity, which is of considerable value in certain chest and abdominal examinations.

The Bucky Diaphragm

As used for elimination of fog, in the radiographing of deep structure is a modification of the original diaphragm described by Bucky some few years ago, the objectionable features of the presence of the grid having been re-

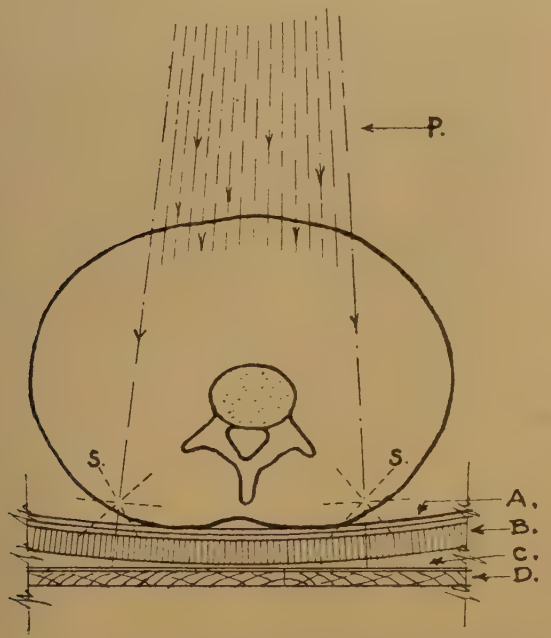

Fig. 1.—Schematic representation of primary rays (P) and scattered rays (S) which are cut off by the faces of grid (B) before arriving at plate (C).*

moved by a moving carriage without the loss of any of its function.

In brief we may describe it as strips of metal placed parallel to each other and separated equal distances by gutted wooden strips. These are set in a section of a shell of a cylinder with sufficient curve to permit of the rays passing through the spaces between the metal at a distance of 25 inches from the plate without impinging on

*Hollis E. Potter, Am. Jour. Radiology, June, 1920.

the sides of the strips. The whole is mounted on roller bearings and runs on a curved track. The speed is controlled by friction and the power by spring or compressed air. By way of illustrating the action of the Bucky, Fig. 1 (taken from the June, 1920 number of *American Journal of Radiology*) will show the source and direction of the scattered rays flooding in from every point and striking the plate, causing fog and limiting the value of negatives, and the important part the grid plays in blocking these rays from the plate.

Until the development of the diaphragm we have only been able to somewhat limit or modify the action of these scattered rays by lowering the backup and increasing the time, with but a limited result and an increased danger of injury.

The technic in general for use of this diaphragm is as follows: The patient is placed upon the structure in such a manner as to bring the part to be radiographed in line with center of the cover and is then fixed against movement. The tube is placed above at a distance of 25 in. from the plate and so fixed that the central rays will fall directly over middle of diaphragm.

The film with its double screens is placed directly beneath the traveling arc. The movable grid is set and so timed that when released the carriage will be in full motion during the full exposure. The patient is told to remain quiet and to hold his breath, the trap is sprung and exposure is made.

Target Adjustment

It must be remembered that we cannot always adapt the part to be examined to the position of best definition by reason of the character of the injury or the nature of the pathology, and in consequence we must adapt our tube and plate to the part. Anatomic construction like-

wise influences the position and manner of production of efficient radiograms. With a thorough knowledge of the anatomy and a modern flexible tube stand, we can obtain a most satisfactory result of practically any and all parts of the body under reasonably normal conditions. The prime thing to remember in the plating of a part under any and all circumstances, is to have your target so centered that the principal rays fall over the center of the part to be radiographed and perpendicular to the plane of the plate; but where this is impracticable or undesirable, one should have the tube so adjusted and tilted that the central rays will come to a focus over the essential part. When the rays fall at an angle to the plane of the plate other than a right angle, the shadows are more or less distorted, and this in a fractured bone would be misleading. But in certain cases, such as mastoid tracings where distortion cannot be avoided in order to eliminate the overlapping of shadows of the opposite mastoid, due allowance must be made in the reading. This applies also to the frontals, certain views of the mandible, and to stereoscopics when viewed singly.

In speaking of the principal or central ray, the author refers to that emanating from a source which, passing through the center of a limiting diaphragm, will change its direction with each tilt of the tube and its mounting; while the central ray, when the tube is beneath the table and the target is so adjusted that the line joining the focal spot of the target with the center of the diaphragm opening is vertical, is known as the vertical ray.

It might be well to mention here the necessity of a properly constructed illuminating screen, since proper illumination is a marked essential in the interpretation of plates, and is consequently a factor in laboratory equipment.

These screens may be made in any size and shape as best meets the requirements of the operator. They are

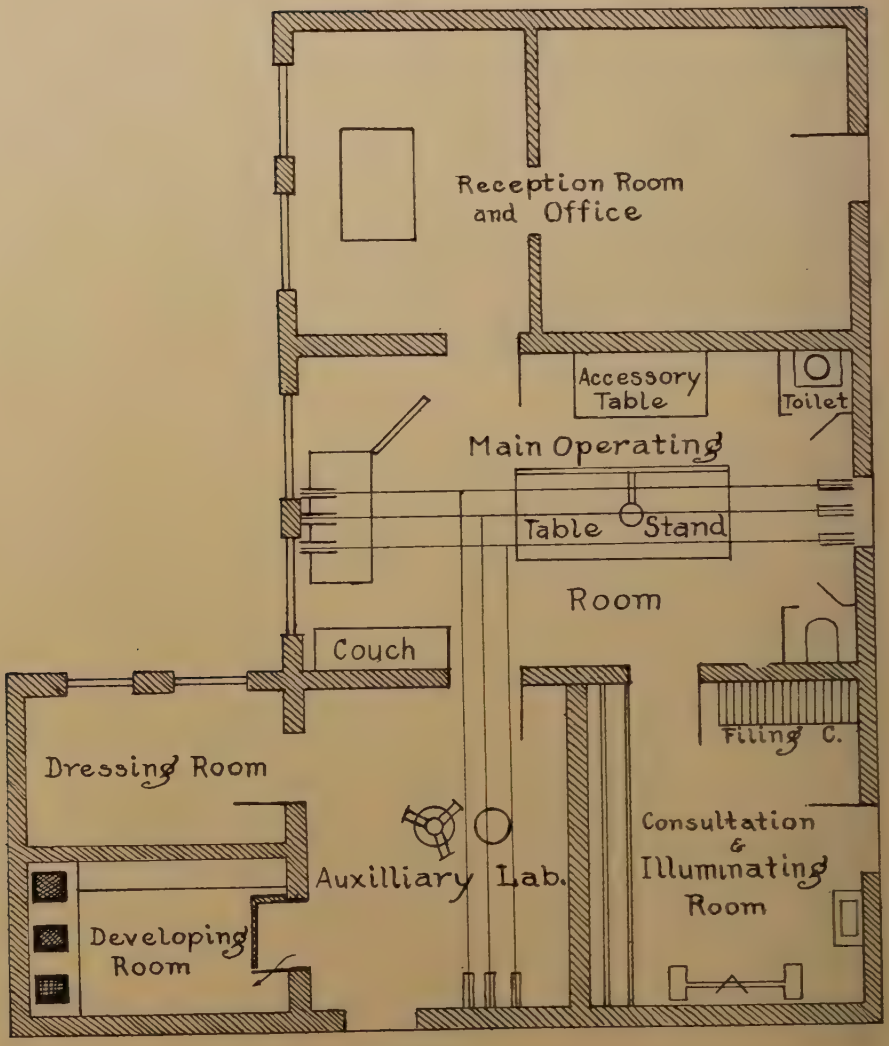

Fig. 2.—Author's laboratory.

made of well-seasoned wood with back, bottom and top solid except for angulated ventilators, while the front built to slope at an angle of about 10 degrees, is but a frame set on hinges and filled in with a good grade of a fine ground glass and set in two sections, one above the other and separated by a strip of wood 4 inches wide. On this strip, and facing towards the rear of the box

Fig. 3.—Chair and stand suitable for dental radiography.

is placed a series of 100 watt blue glass nitrogen lamps. The light control is that of a rheostat which limits the amount of illumination. The interior of the box should be painted heavily with a gloss enamel of pure white. One will find in this a most satisfactory box and one free from the objectionable local spots of intense illumination. A similar box of smaller construction, with several layers of ground glass with air space separation, is a val-

uable adjunct to a laboratory for wet-plate study.

Good stereoscopic negatives, when viewed in the stereoscope, show perfect pictures with the correct prospective for the parts shown; therefore a stereoscope should be added as part of the necessary equipment. The large adjustable box type with Cooper-Hewett light is to be desired, but, where such is not available, a small Pirie

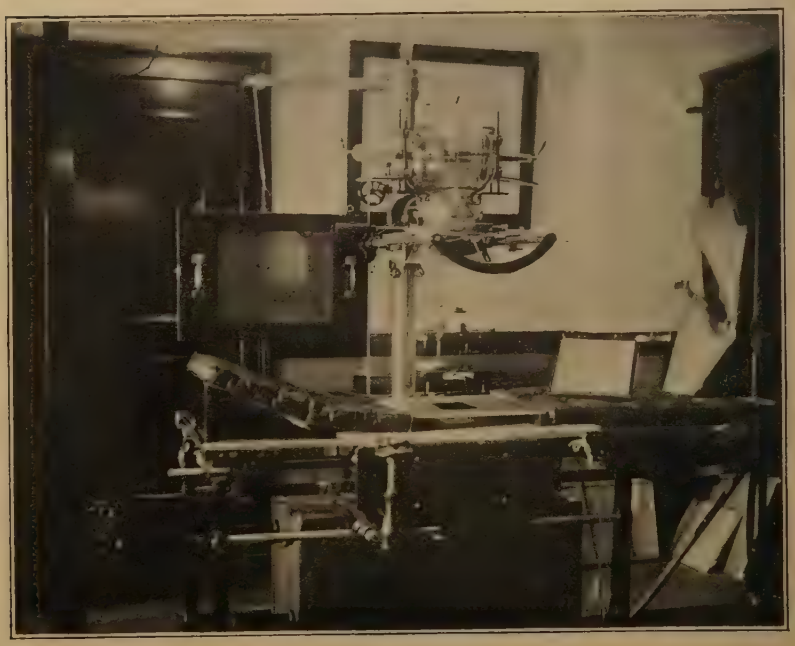

Fig. 4.—Pylorogram.

hand stereoscope will be found useful and reasonably effective.

Body and eye localizers are likewise a necessary adjunct to the armamentarium of a properly equipped laboratory, and these, to be effective, must be more or less accurate. Types and means of localization will be taken up later under "Methods of Localization."

A small examining chair, such as is used by the nose

and throat men, will answer nicely for intraoral dental work, since it is reasonably rigid and with sufficient head rest for stability and support. Radiographs of the teeth can be taken lying on the table, but this is often impracticable and frequently objected to by patients, especially by women (Fig. 3).

The pyelogram is a valuable adjunct for gastrointestinal work in that it permits of serial radiographs in fractional seconds of moving parts (Fig. 4).

Marking Plates

When a considerable amount of radiographic work is done, it is well to organize some system of identification. The name of the patient should be written on the envelope or attached to the casette at the time of exposure, and later transferred to the film side of plate, in the developing room, by means of a soft lead pencil. Likewise lead numbers should be placed over one corner of the plate at the time of exposure, which will correspond to file record of case, along with date of taking.

It is an undisputed and accepted fact that it is the man and not the equipment that produces the results, but for expeditious work and positive results a complete equipment and a carefully arranged laboratory materially limits failures by removing, to a degree, the personal equation. It is well, therefore, to equip, if possible, with as complete and compact an apparatus as conditions will permit, in order to expedite one's examination, to secure as much floor space as possible and with as little outside light as practicable, and at the same time so divide up the space as to allow of a developing room, separate illuminating room, and dressing rooms. Figure 2 shows a ground floor plan of the author's laboratory divided so as to allow work to the best advantage in conformity with the average public building.

CHAPTER III

STANDARDIZED POSITIONS

In order to make a correct interpretation it becomes necessary to accept some standard relation between the source of the rays, the plate, and the part to be examined; therefore, in taking up the question of position, it is the endeavor of this work to delineate by means of a model the positions which from experience have given the best diagnostic results.

Unless some standard is accepted, it is quite possible distortions will occur which would render plates doubtful. This is especially so of fractures.

Fractures.—From a radiographic standpoint we divide fractures into but two classes, which in turn are subdivided according to direction into the simple and comminuted.

The examination of fractures is usually made by plating, although in some cases advantage is to be gained by fluoroscopy where it is a question of time and expediency. It also allows of a rapid survey of parts outside the approved field of injury, which may be involved yet present no clinical evidence. The principal disadvantage to the fluoroscope is in the lack of texture detail.

In plating fractures it is important, especially in fractures of the long bones, that the position of the part, the target and the plate be exact and parallel and that the time and ray penetration be properly selected, otherwise the alignment is defective and the internal structure is lost.

Beside the above precautions it is important that the part be put in a position of complete relaxation and se-

cured by sand bags against movement, otherwise a hazy picture is obtained as the result of part movements in toto and muscular spasm. It is well to mark the plate either with a soft lead pencil or lead figures "right" or "left" and "top" or "bottom," since this obviates mistakes and facilitates the interpretation.

When the fracture is badly comminuted, it is advisable also to take stereoscopics so as better to appreciate the relative positions of the several fragments.

Splints, casts, etc., should never be removed except by the attending surgeon, and satisfactory plates can be made without this procedure by allowing for additional densities, and arranging time and penetration accordingly. Pins, however, should be removed during the time of the exposure to eliminate the possibility of error in diagnosis.

Bedside plates of fractures are sometimes required, but on the whole are unsatisfactory, due to instability of the part through lack of means of proper immobilization and insufficient appliance for portable radiography. When it is imperative that this work be done at the bedside and especially at the home, the technic should be simplified as much as possible with the hope that the result may be reasonably satisfactory.

Dislocations, like fractures, come to the laboratory and are treated under the general technic as applied to fractures. Fluoroscopy is, however, to be accepted in these cases in preference to plating.

The question of the reduction of fractures under the screen is to be condemned in general as it is fraught with unnecessary dangers to the surgeon and the patient.

Skull and Accessory Sinuses.—The skull lends itself to three principal positions for skiagraphy: (1) the lateral, which furnishes excellent detail of the general contour, frontals, antrum, and basal articulations; (2) the anteroposterior or posteroanterior with its delineation

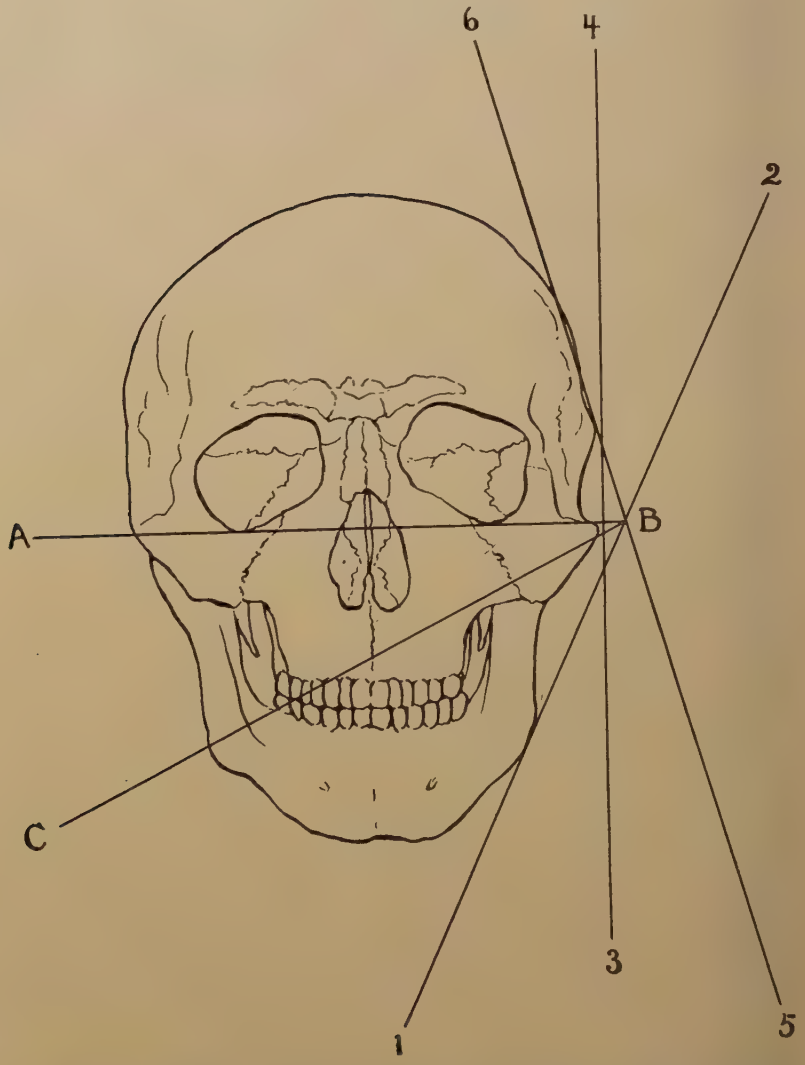

Fig. 5-A.—Schematic drawing illustrating correct angles for lateral of head and mandible. *3-4.* Plane of plate for lateral of head and sinus. *A-B.* Direction of principal rays for lateral of head, etc. *1-2.* Plane of plate for mastoids. *C-B.* Direction of principal rays for mastoid. *5-6.* Plane of plate for inferior maxillary bone. *C-B.* Direction of principal rays for inferior maxilla.

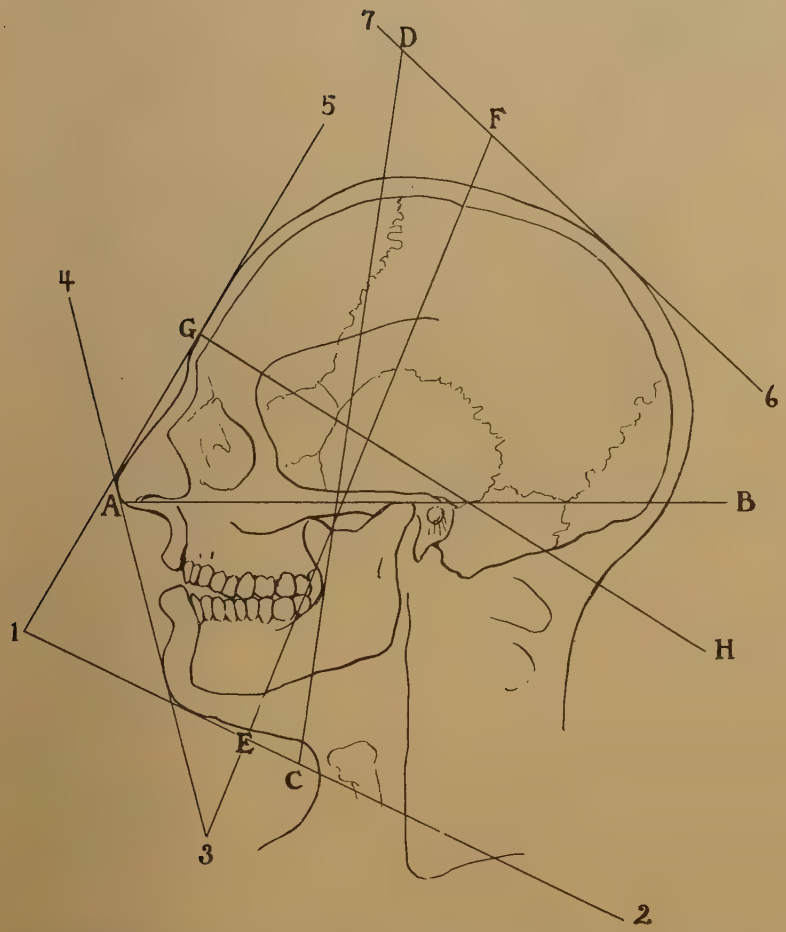

Fig. 5-B.—Schematic drawing illustrating correct angles for sinus examination. *1-5.* Plane of plate with a 23 degree of angulation. *G-H.* Direction principal rays for frontal sinus. *A-B.* Direction of principal rays for frontal, ethmoid, and antrum. *3-4.* Plane of plate with 23 degree angulation for all sinuses. *1-2.* Plane of plate for superoinferior of sphenoid sinus. *D-C.* Direction of principal rays for inferosuperior of sphenoid. *6-7.* Plane of plate with 23 degree angulation for inferosuperior of sphenoid sinus. *E-F.* Direction of principal rays for inferosuperior of sphenoid sinus.

of the antrums, ethmoids and frontals; and (3) the infero-superior for the sphenoid and vault fractures. These with their modifications will permit of a more or less complete tracing of all parts of the cranium, face and mandible (Figs. 5-A and 5-B).

Tube.—On account of unstable vacuum of gas tubes under heavy charge and the great flexibility of the Coolidge, all technic is based upon results obtained by medium focus Coolidge tube.

The technic as here given is worked out on a normal subject of the proportionate thickness and weight as given on page 23. Time variations from those given, must be worked out on the law of inverse square and density.

Kilovolts are given in the technic of all the standard positions, since it is considered a much more reliable guide to tube output than the spark backup, which latter is influenced by atmospheric conditions. The measurements are made on an electrostatic high tension voltmeter, the primary kilovoltmeters being unreliable.

Filters.—Repeated exposure at short distance may cause damage to the patient. In consequence of which it is wise to use 1 mm. filter of aluminum. This does not cut off any of the penetrating rays, but retards the soft ones. Filters, therefore, are mentioned in the additional technic and should be used accordingly.

Technic for Antra, Nasal Fossa, Orbits, Etc.

Anteroposterior.—The patient should lie face down on the table, or seated firmly in an arm chair if operating from a suspended platform of the tube stand. The head is best supported by clamps to prevent movement, and should rest on the mental process of the mandible and the tip of the nose. In operating from a table, this position is best secured by the use of a platform such as is

obtained in the Sweet Eye Localizer and especially so if stereoscopic views are to be made, or on one of the various combination platforms as supplied with the more modern tables. The target is centered over the median line about 2 inches above the occipital protuberance and at right angles to the plane of the plate, and in line with

Fig. 6.—Anteroposterior head position.

and parallel to the lower border of the zygomatic process (Fig. 6). With the patient so placed, the tube should be adjusted to the required distance and the following general technic used:

Time is reckoned on duplitized films. If plates are used increase exposure approximately one-half second for every second of exposure.

Cone—8 inch. Diaphragm—5 inch. Filter—1 mm. of aluminum. Distance—20 inches. Milliamperage—35. Gap—5 inches. Kilovolts—60. Plate—8x10. Time—7 sec. or 1½ sec. double screen.

Lateral of Head.—With the head supported on a plane and rotated so that it assumes an angle of 90 degrees to

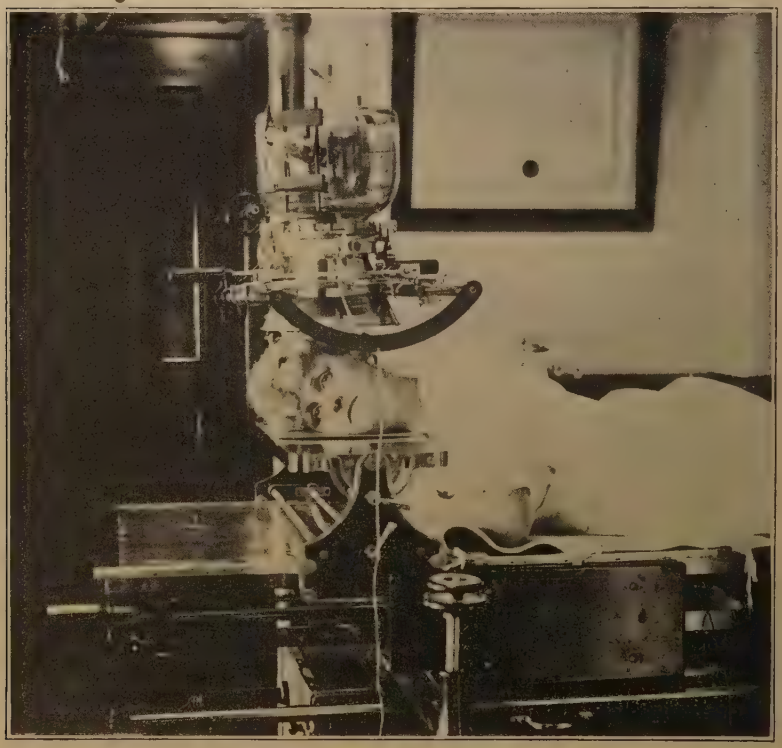

Fig. 7.—Lateral head position.

the body and resting flat to the surface of the plate or stereoscopic tunnel, the central rays are made to fall in line with the external meatus and about ½ inch above the helix of the ear. Fixation of the head in the laterals is usually unnecessary as the part will remain steady from its position (Fig. 7).

The following additional technic is suggested as furnishing the best definition:

Cone—8 inches. Diaphragm—5 inches. Filter—1 mm. aluminum. Distance—25 inches. Milliamperage—35. Gap—5 inches. Kilovolts—60. Plates—8x10. Time—5 sec. or 1 sec. double screen.

Inferosuperior.—This position is for the delineation of vault injuries, sphenoids, etc., and is to be obtained by

Fig. 8.—Inferosuperior head position.

placing the patient on the table with the shoulders drawn well up and in line with the end of the table, thus permitting the head to hang over and down in such a manner as to contact with an adjustable stool on which rests the plate. The rays are then directed through a small cone and centered midway between the symphysis of the inferior maxillary and the styloid processes of the temporal, and at right angle to the surface of the plate (Fig. 8).

For fractures at the base and pathology of the lower middle and anterior fossa it is advisable to place the plate below the mandible.

The following additional technic is advised:

Cone—5 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance 20 in. Milliamperage—35. Gap—5 in. Kilovolts—60. Plate—8x10. Time—1 sec. double screen.

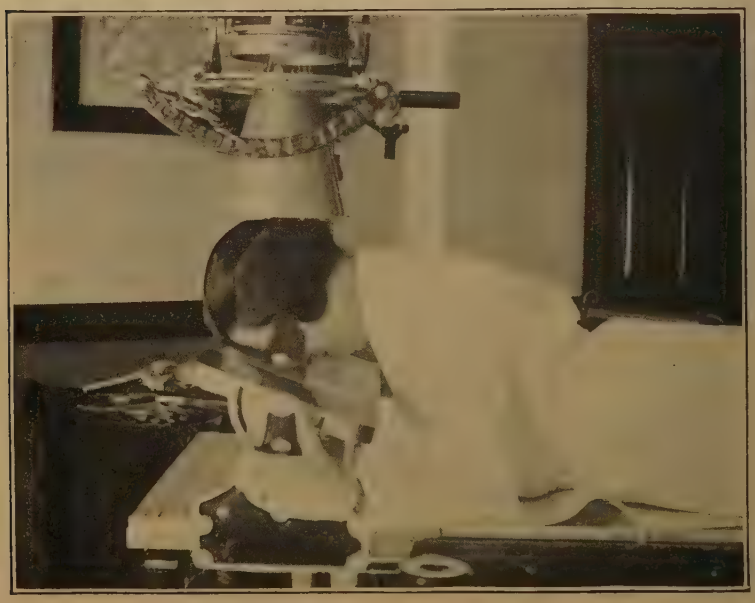

Fig. 9.—Position for frontal sinus.

Frontal Bone.—For a detailed definition of the frontals the patient is placed face down with the forehead resting on the plate, the glabella being in close contact. This is best accomplished by using a tilt of 23 degrees to the plate support and the central rays made to fall in the center of the glabella. Using the following technic in addition to the foregoing directions will give a perfect definition of the frontals or of an injury to the bony structures (Fig. 9).

Cone—5 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—20 in. Milliamperage—35. Gap—5 in. Kilovolts—60. Plate—8x10 and 5x7. Time 6 sec. or 1 sec. double screen.

Occipital Bone.—It quite frequently happens that one is required to make a thorough radiographic examina-

Fig. 10.—Occipital position.

tion of the occipital bone; and to do this requires a special technic. The patient is placed on the back with the head supported on an incline of 23 degrees on which rests the plate. The tube is now brought down to a position and slightly tilted forward to permit the central rays to enter the forehead between the frontal eminences. This will give an excellent skiagram of the foramen magnum and mastoids, as well as of fractures occurring in this field (Fig. 10). For additional technic the author suggests the following:

Cone—5 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—20 in. Milliamperage—35. Kilovolts—60. Gap—5 in. Plate—8x10. Time—7 sec. or 1½ double screen.

Stereoscopics are possible and at times desirable. The difference of technic is in the shift, tilt and time increase of about 1 second.

Mastoids.—A direct frontal or lateral view will not show distinctly or accurately the mastoid cells, since the overlapping of the structures of the one side makes a confused mass of densities in the lateral and the frontal view shows but the anterior base, which to a limited extent is of value as a check on the oblique. There is only one method which will give a proper definition from a diagnostic standpoint.

Place the patient face down on the table with the head supported on a sinus block or one of the constructed table superstructures which has been adjusted to an angle of 23 degrees with its base parallel to the line of the shoulders and away from the body. The central ray is made to fall ½ inch posterior and 2 inches above the pinna of the ear. In all cases it is advisable to draw the pinna forward and fix with adhesive before making the exposure, in order to clear the field of additional shadows. Both mastoids should be taken in every case as the one

acts as a control for the other (Fig. 11). The plates should be marked "right" and "left" or 1 and 2 at the time of taking in order to avoid confusion.

In addition to the above, the following technic should be used and the results will be quite satisfactory:

Cone—3 in. Diaphragm—3 in. Filter—1 mm. of

Fig. 11.—Position for mastoid.

aluminum. Distance—25 in. Milliamperage—50. Kilovoltage—60. Gap—5 in. Plate—5x7 or 10x12 using half for each mastoid. Time 1 sec. fine grain double screen.

Mandible.—The inferior maxillary is an important bone from a radiographic standpoint, since it is the seat of much injury and no little pathology from the view-

point of the neurologist and dentist. There are but two methods of demonstration: extraoral, or plating from the outside, which includes the entire bony structure; and the internal, or intraoral, which by means of small films placed within the mouth permits of finer delineation of a limited character. The latter method is accepted as the

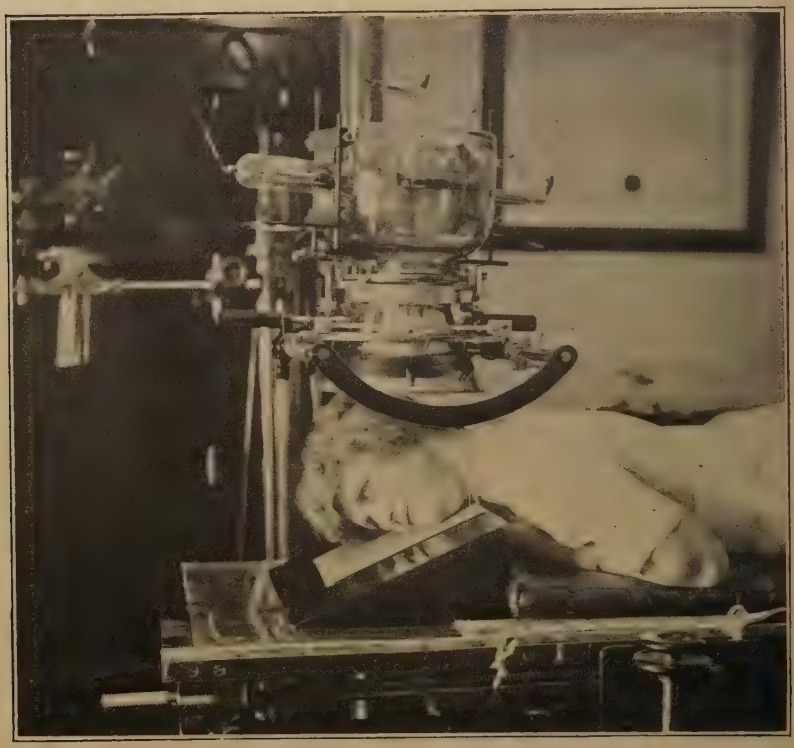

Fig. 12.—Mandible position (lateral).

best for most of the dental and small traumatic lesions, while the former is unquestionably the best for general surgical and pathological orientation, in that it gives a larger field and better detail of the temperomaxillary articulation, of the angle of the jaw and the mental foramen.

For the external or plate method the patient is placed face down on the table with the head supported on an

incline of 25 degrees with the base of the triangle at right angle to the long axis of the body and with the chin slightly tilted forward but in close contact with the plate. The central rays are directed to fall in line with

Fig. 13.—Mandible position (anterior).

and ½ inch behind the angle of the jaw. This will of necessity throw the plate out of line with the perpendicular rays and cause some slight distortion as to size, but it will eliminate the overlapping of shadows which must be avoided if we would get a clear definition of the mandible. It is advisable in every instance to plate both sides for anomalies and for comparison (Fig. 12).

For the anterior, or mental portion of the mandible, the patient should be placed as for an anteroposterior of the head, and the part should be fixed against movement. The central ray is then made to fall in line with the spine and at a point corresponding with the second cervical vertebra. (Fig. 13.)

For an exposure of the inferosuperior of the mandible, the patient should be placed on the back well up on the table. With the head dropped over the end, a large film is

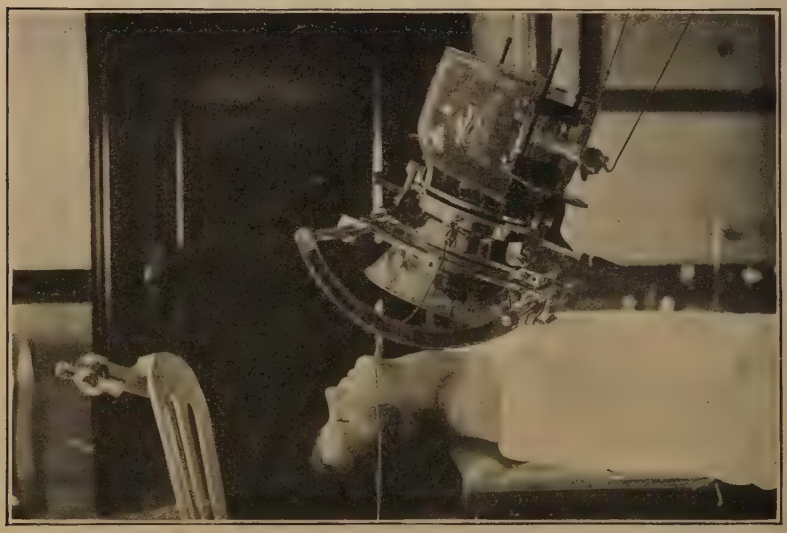

Fig. 14.—Inferosuperior position of mandible.

placed between the teeth and the tube tilted to such an angle as to permit the central rays to fall just inside of the jaw (Fig. 14).

Additional technic for radiographing the mandible follows. For laterals and the anterior part of the mandible:

Cone—5 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—20 in. Milliamperage—35. Gap—4 in. Kilovolts—50. Plate—8x10. Time 1½ sec. double screen.

CHAPTER IV

SPINE AND PELVIS

From a radiographic standpoint the spine presents four divisions and three aspects with the exception of the sacrum which permits of but an anteroposterior and a stereoscopic, either horizontally or longitudinally. Of the divisions, we have the cervical, the dorsal, the lumbar, and the sacrum and coccyx; while of the positions, the anteroposterior furnishes the best definition on account of the approximation of the vertebral discs to the plate. An oblique and lateral is possible and should be taken especially in case of fracture. In considering the technic of this part of the body it becomes necessary to deal with the separate divisions on account of the adjacent structural tissues, the different densities, and the varied curvatures.

Cervical Spine.—This includes all that part of the vertebral column from the occipital articulation to and including the seventh vertebra, which is easily recognized by the prominence of the spinous process. This in turn must be divided anteroposteriorly into two parts, since it is impossible to radiograph the first three vertebræ with the remaining four and obtain a definition of the entire cervical section. Likewise, the positions necessary for spinal definition here are equally essential for satisfactory skiagraphic work of the larynx, trachea, etc.

The atlas, axis and third vertebra are radiographed through the open mouth with a small cone for the anteroposterior and a larger cone for the lateral. In the anteroposterior position the patient having first been placed on the back with the head extended, the mouth is opened to

its fullest extent and fixed with a piece of cork set to the side and well back between the teeth, and the plate put into position directly beneath and well up on the occiput. The central rays are made to fall through the open mouth (Fig. 15).

Fig. 15.—Anteroposterior position for atlas and axis.

The following technic as to time, etc., follows:

Cone—3 and 5 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—25. Gap—5 in. Kilovolts—60. Plate—5x7 and 8x10. Time —4 sec. or ¾ sec. double screen.

The lateral of the first three vertebræ is the same as for the entire cervical except for the size of plate.

The anteroposterior of the cervical is made by placing the patient on the back well up on the table and with the head extending slightly over the edge in such a manner as to allow the chin to be well raised. The plate placed beneath and extending from the occiput to and a little below the seventh cervical vertebra permits of a com-

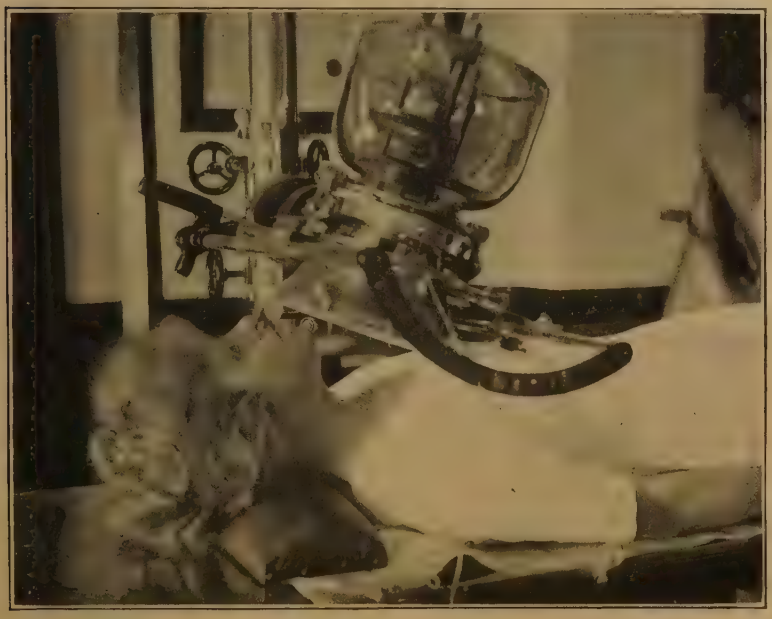

Fig. 16.—Anteroposterior position for cervical spine.

plete delineation of the vertebræ. The central ray should be perpendicular to the plate and made to fall in line with the thyroid cartilage. The exposure, distance and time are the same as for the first, second and third vertebræ). (Fig. 16.)

Lateral of Cervical Spine.—Have the patient sit in an upright position with the head fixed in a support to insure stability. With the plate held by an assistant paral-

lel to the long axis of the body, the tube is tilted and centered over the middle of the plate and parallel to its plane at a distance of not more than 20 inches. This will insure a perfect definition; and if the plate is pressed well

Fig. 17.—Lateral position for cervical spine (sitting).

down on the clavicle the entire cervical vertebra will be clearly defined (Fig. 17). Another method of reaching this same result is by placing the patient on the back with the plate pressed against the side of the head and neck and there supported by sand bags or other means. One should see that the shoulder is drawn well down

so as to insure the certainty of getting the entire cervical region. The tube is placed off to the side with the principal rays falling at right angle to plane of plate (Fig. 18). The following additional technic is suggested as to time, etc.:

Cone—10 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Gap—5 in. Kilovolts—60. Plate—10x12. Time—4 sec. or ¾ double screen.

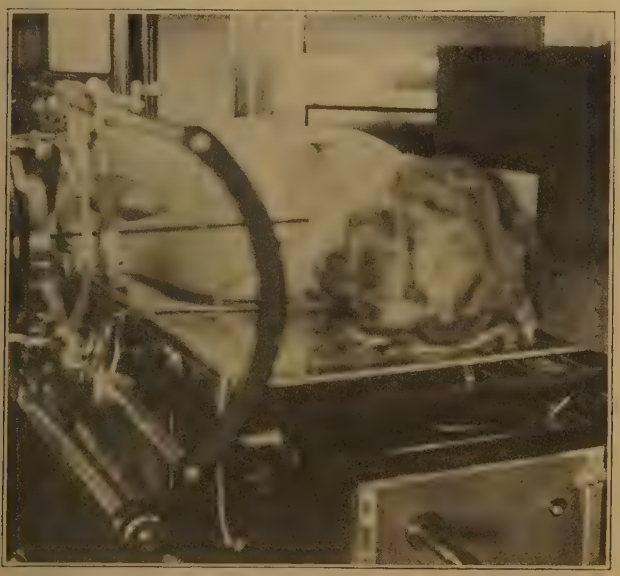

Fig. 18.—Lateral position for cervical spine (recumbent).

The larynx should be plated laterally and stereoscopically from an anteroposterior position with about the same time, milliampèrage, and distance as for the cervical spine.

Thoracic Vertebra.—Anteroposteriorly these vertebræ may be taken on one plate or what is better two smaller ones. In preparing a patient for the exposure, place the patient on the back with the plate beneath, and center the tube so that the principal ray passes through the body

and strikes the plate perpendicular to its plane and in the center of its field, whether one large or two small plates be used. In considering the additional technic we must consider the densities of the diaphragm and other superimposed tissue, and time the exposure accordingly (Fig. 19).

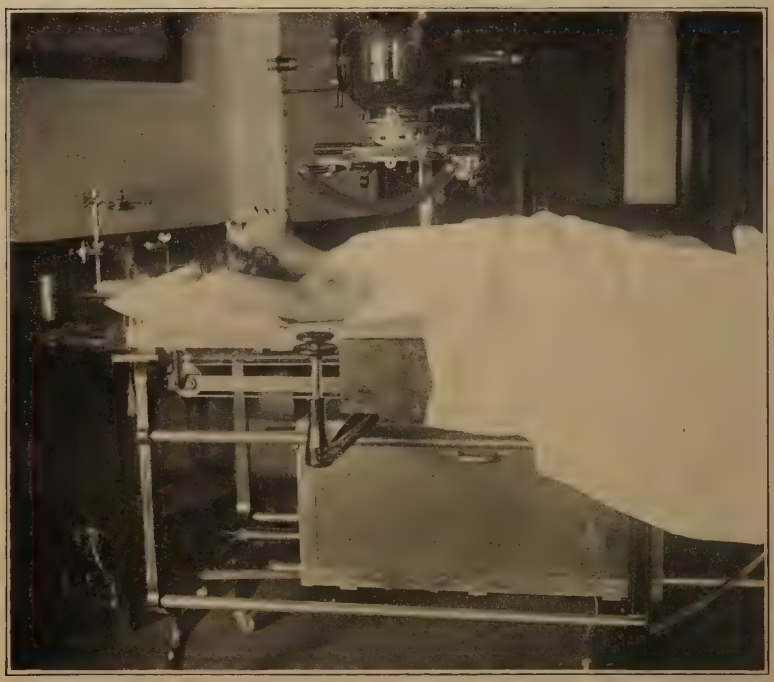

Fig. 19.—Anteroposterior position for dorsal spine.

Cone—10 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—25. Gap —5 in. Kilovolts—60. Plate—11x14. Time—3 sec. double screen and Bucky Diaphragm.

Lateral Thoracic Vertebræ.—The patient is placed on the table and made to lie on the side with the arms extended above the head and a single plate of sufficient size to include the entire thoracic vertebræ is placed beneath.

The central rays are now made to fall perpendicular to the plane of the plate and in line with the nipple. The patient can be supported and steadied by flexing the knee and by a block placed back of the head (Fig. 20).

Cone—none. Diaphragm—7 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—25. Gap —5 in. Kilovolts—60. Plate—11x14. Time—double screens and Bucky Diaphragms—5 sec.

Fig. 20.—Lateral dorsal spine position.

Lumbar Spine.—The lumbar spine permits of an anteroposterior and lateral delineation even to that of the 5th vertebra. Both positions are useful in determining injury and disease; and care should be exercised in producing true radiographs, taking into consideration the curvatures of the midlumbar so as to prevent an overlapping of the shadows.

In obtaining this end from an anteroposterior viewpoint, it is necessary not only to place the patient on the back and elevate the knees or perhaps the shoulders to secure proximity to the plate, but the tube should be so placed as to permit the central rays to strike perpendicu-

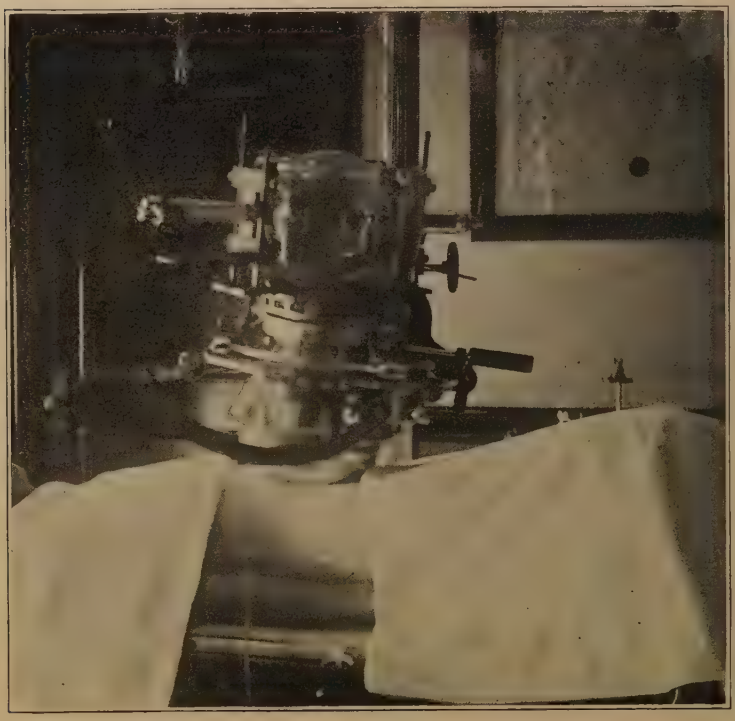

Fig. 21.—Anteroposterior lumbar spine position.

lar to the long axis of the spine: this is to be accompanied by a forward tilt of the tube. (Fig. 21.)

Cone—11 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—Compression or Bucky Diaphragm—25 in. Milliamperage—35. Gap—5 in. Kilovolts—60. Plate—11x14. Time (compression)—5 sec. or 3 sec. double screen and Bucky Diaphragm.

Lumbar Spine (Lateral).—Patient should be placed on the side with the knee drawn up for support and with the plate beneath. The central rays are made to fall in line with the vertebræ and midway the length of the plate. This applies to the entire lumbar vertebræ with the exception of the last vertebra, which, in itself, on account

Fig. 22.—Lateral lumbar spine position.

of the superimposed structures, requires a special technic (Fig. 22).

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—20. Gap—7 in. Kilovolts—80. Plate 11x14. Time—fine grain double screen Bucky Diaphragm 7 sec.

For the lateral of the 5th lumbar vertebra, it is advisable to use a small plate placed directly beneath the field.

At a distance of about 28 inches the central ray is made to fall directly on the vertebra and perpendicular to the plane of the plate.

It is necessary in radiographing this vertebra that we make use of the screen and at the same time increase our milliamperage to 50 ma. Approximate the tube as near as possible according to the thickness of the individual

Fig. 23.—Anteroposterior position for pelvis in toto.

and with a 6 inch backup time your exposure from 10 to 15 seconds.

It sometimes becomes necessary, in order to obtain some additional definition of parts of the vertebral column, especially of the lower dorsal and lumbar vertebræ, to take oblique radiographs; and to accomplish this the patient is placed on the back and rotated to an angle of

about 60 degrees and there supported by sand bags. The exposure varies little from the anteroposterior, probably in an increase of one to two seconds in time.

Pelvis.—This region requires most careful study from a roentgenologic standpoint, both for trauma and disease; consequently, it is imperative that the plate work must be of a superior character. Owing to its shape and posi-

Fig. 24.—Position for sacrum and sacroiliac articulation.

tion in its relation to the vertebral column, it offers but two positions, the anteroposterior and the posteroanterior. For a general survey of the entire pelvis, an anteroposterior without compression is the best (Fig. 23); but where a detail delineation of the sacrum and coccyx is essential, it is best to take the part under compression with a full-sized cone, or if but the sacrum and coccyx

alone are to be plated, a small cone under compression and tilted upwards to an angle of about 20 degrees will give the best results (Fig. 24). For stereoscopics the anteroposterior, at a distance of about 26 inches, will furnish excellent results.

With Bucky Diaphragm

PELVIS, SACRUM AND COCCYX

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—30. Gap—6 in. Kilovolts—70. Plate—11x14. Time—double screen 3½ sec.

Without Bucky Diaphragm

PELVIS

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—23 in. Milliamperage—35. Gap—5 in. Kilovolts—60. Plate 11x14. Time—7 sec.

SACRUM

Cone—7 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Milliamperage—35. Distance—compression. Gap—5 in. Kilovolts—60. Plate—8x10. Time—5 sec.

COCCYX

Cone—3 in. Diaphragm—3 in. Filter—1 mm. of aluminum. Distance—compression. Milliamperage—25. Gap—4 in. Kilovolts—50. Plate—5x7. Time—double screen 2½ sec.

Hip.—On account of the close affiliation, both surgically and anatomically, of the hip and pelvis it is here taken up for radiographic consideration.

In plating this part of the body it is advisable to include both joints, as a matter of comparison, and to obtain

this end satisfactorily the tube must be centered just below the symphysis of the pubis. This will give a reasonable detail of the head of the femur and the acetabulum. The joint itself, however, sometimes requires a more accurate definition, and to obtain this it becomes necessary to take separate views of the hips, either flat or stereoscopic. Both methods are useful, but unquestionably the

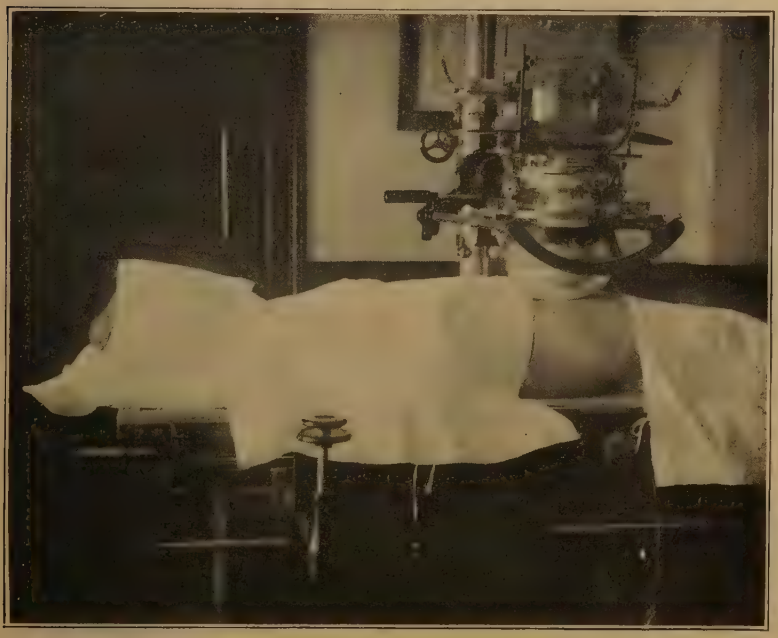

Fig. 25.—Anteroposterior hip position.

stereoscopic is the most accurate, since the angle of the shift can be accommodated to the character of the injury or malformation.

The patient should be placed either on the back or face downwards, usually the latter for the first radiograms; and the limb should be so arranged as to give the best definition from the point of articulation. This should show the head of the femur, the cotyloid notch, the rim

of the acetabulum superimposed over the head of the bone, the greater and lesser trochanters, and the upper shaft of the femur. The central rays are directed to fall over the femur and a little to a line inside the iliac crest. A skiagraph should now be taken with the patient on the back, the central rays being directed to a point 2 inches below and 2 inches inside the anterosuperior spine of the ilium (Fig. 25).

Where, in the case of fracture, it is inadvisable or impossible to place the patient on the face, the plate can be placed above the part and the ray directed from the tube beneath the table.

Only the middle and lower part of the shaft of the femur can be taken laterally, consequently in case of injury or fracture high up or involving the head of the femur along with the shaft, the only method at our control, from a truly satisfactory standpoint, is the stereoscopic.

With the position established, the following technic will be found to be satisfactory:

Cone—10 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—20 in. Gap—5 in. Kilovolts—60. Milliamperage—30. Plate—10x12. Time—6 sec. or 1½ double screen.

In taking stereoscopics of the hip it is only necessary to increase the time from ½ to 1 second, according to the distance, and at the same time remove the cone.

CLAVICLE, SCAPULA, STERNUM, AND RIBS

CHAPTER V

Clavicle.—The clavicle may be radiographed in its entirety, or sectionally, and one or both as the case may warrant.

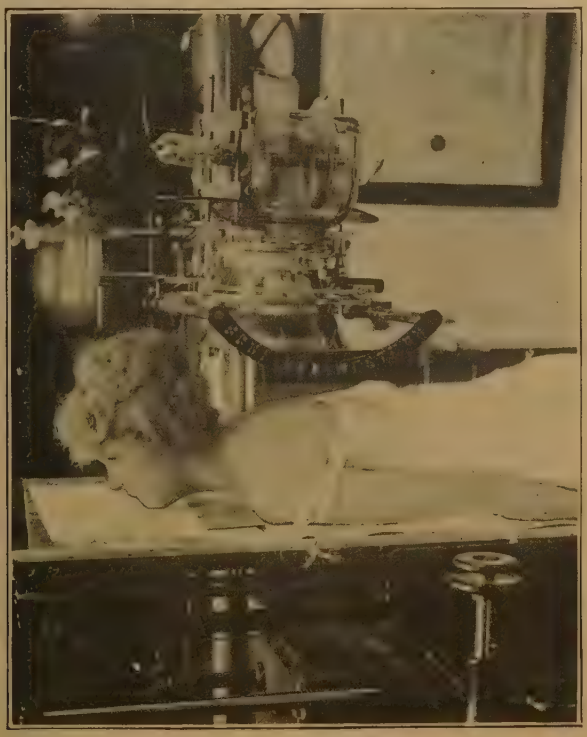

Fig. 26.—Clavicle position.

The sternoclavicular articulation is best shown with the plate placed on the anterior wall of the chest. The scapular articulation is best defined with the plate

against the posterior wall, with the principal or central ray directed to fall over the manubrium. From the reverse position the central rays should be directed over the second or third dorsal vertebra. These positions are for the radiographing of both clavicles at one time, since it is rarely advisable to take but one clavicle. In consequence of this accepted technic, always use large plates so as to include both bones in their entirety.

With the patient placed on the face or back as desired, use the following technic (Fig. 26):

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—30. Gap—4 in. Kilovolts—50. Plate—8x10 or 11x14. Time—4 sec.

Scapula.—In radiographing the scapula it is advisable to place the patient on the back, with the arms partly extended above the head in order to clear the shadows of the cardia and mediastinum. The plate should be placed crosswise to the length of the body and be of sufficient size to include both scapulæ while the central rays are directed to fall over the sternum at about the fourth sternocostal articulation.

If but one scapula is to be radiographed, the principal rays are directed to fall about 2 inches below the clavicle and just outside the mammillary line, or in proportion to the height of the extended elbow.

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Gap—4 in. Kilovolts—50. Plate—10x12. Time—4 sec.

Sternum.—On account of the possible confusion of the shadows of the mediastinum and the vertebræ, it is necessary that the patient be rotated about 30 degrees to the left. This can be done lying face down or taken in the vertical position with the right shoulder resting against plate. This latter position has the advantage of minimiz-

ing the heart shadows, and in case of enlargement it is of no small moment.

With the plate parallel to the long axis of the body the central rays are made to fall 3 inches to the right of the vertebral column and in line with the third and fourth dorsal vertebræ. In addition to the above, the following technic should be used:

Fig. 27.—Position for radiographing scapula.

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—20. Gap—4 in. Kilovolts—50. Plate—11x14. Time—3 sec.

Ribs.—The ribs can be radiographed *en masse* anteroposteriorly, posteroanteriorly, and laterally, according to the requirements of the case. For a localized point of

trauma or disease the seat of investigation should be brought in as close contact as possible with the plate, and the principal rays should be directed in such a manner as to fall at right angles to the plane of the plate and directly over the field of observation.

For the vertebrosternal and costal ends of the ribs the

Fig. 28.—Position for radiographing sternum.

patient should be placed face downward on the plate, and for the angle and vertebral or short ribs, the anteroposterior is the preferable position. A lateral for angular definition or fracture will often be desired. The above suggestions with the added technic of time, etc., will suffice for practically all conditions affecting the ribs.

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—20. Gap—5 in. Kilovolts—60. Plate—10x12. Time—1 to 2 sec.

Soft Tissue Technic of Chest.—Strict attention to the details and a good routine are most essential in this examination. Likewise, it is most important that the patient be made both physically and mentally comfortable, if a true definition is to be obtained, since the prime factor in all chest work is the screening, while the plating in most instances is but the record file of a condition which may or may not be present.

In preparing the patient for examination, remove the clothing from the part under examination, when possible, or permit nothing more than a simple garment such as a kimono. Allow the patient to become accustomed to the surroundings while you are accommodating the eyes to the darkness, and begin the examination by first adjusting the shutter to a horizontal slit of the width of 2 or 3 inches. Everything is now ready to begin the examination and the patient is placed with the back firmly against the screen support and the illumination carried down over the entire chest until the diaphragm is reached. This will permit of an observation by comparison of any structural change in the lung tissue as well as bony malpositions or pathology. The field of illumination is now slightly increased in width and the excursion of the diaphragm studied. To accomplish this best, the subject should breathe deep, and slowly expel the air by a short, slight cough. The slit in the trochoscope is now changed to the vertical and of such a width as to include the whole apex of the lung, and the patient directed to breathe deep. By this means the extent of the "light-up" of the apex is determined as well as the "spotting" of the lung and thickening of the hili. After examining both lungs in this

manner the whole chest is illuminated by opening wide the shutter, thus permitting of a general survey of the lung tissues and the size and shape of the heart, aorta, etc.

From the position in which the examination has thus

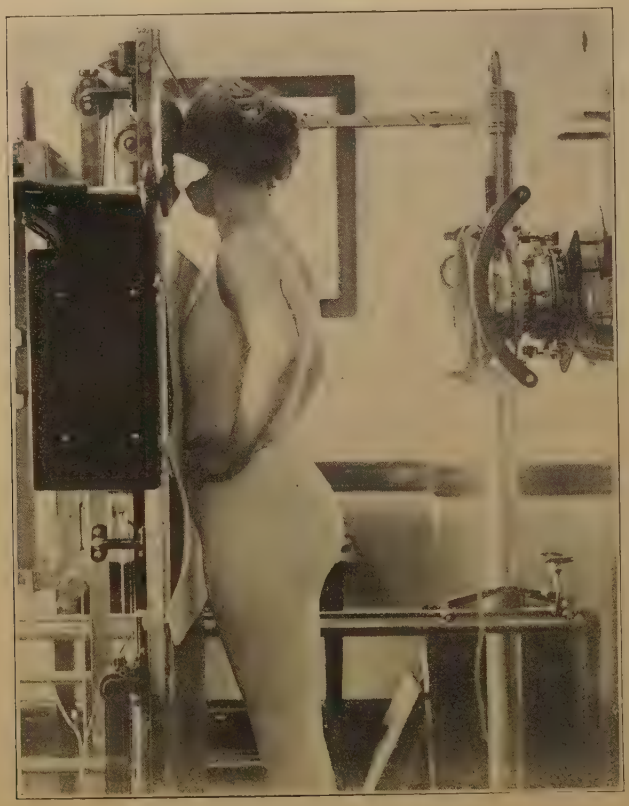

Fig. 29.—Chest position, standing.

far been instituted, the patient is rotated to about 30 degrees; and with the shutter drawn down to a narrow vertical slit, the mediastinum with its vessels and glands and the descending aorta are examined. From this position the subject is made to face the screen support; and with arms extended above the head, the chest is subjected to

another examination similar in manner to the anteroposterior method. If during any part of this examination any abnormalities present themselves, it is advisable to

Fig. 30.—Chest position, lying down.

close down the shutter to the smallest possible opening that is consistent with the field under observation and examine in detail. This applies especially to cavity formation, consolidations, aneurysms and plaques.

It must be remembered that the various tissues of the chest give varied degrees of resistance to the passage of the rays and especially pathologic tissue, and that it is therefore necessary to have means convenient at hand for increasing and diminishing the penetrative power of the rays in order to avoid error of diagnosis.

Fluids in the chest should be screened both vertically and horizontally but should always be plated in the vertical position.

Morbid growths of the mediastinum are best plated in the vertical position and posteroanteriorly. In many instances it is advisable to plate lying down and standing and from both front and back.

Stereoscopics, both anteroposterior and posteroanterior, especially in obscure conditions are the only true and really scientific means of producing a plate for true definition and study.

The object is to reach a correct diagnosis, therefore one should never be satisfied with a simple flat radiogram unless the case is a simple one or unless it has been most thoroughly screened. In making negatives of your findings, plates of such a size should always be used so as to include the entire chest. (Figs. 29 and 30.) The following additional technic is furnished for the making of satisfactory plates:

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—26 in. Milliamperage—25. Gap—5 in. Kilovolts—60. Plate—14x17. Time—1½ sec. or ⅓ sec. with double screen.

HEART

Cone—none. Diaphragm—1 in. Filter—none. Distance—7 feet. Milliamperage—80. Gap—7 in. Kilovolts—80. Plate—10x12. Time—2 sec.

Thyroid Gland.—Place patient on table and rotate head to right or left, according to side of greater glandular enlargement, and have chin tilted upwards. An 8 x 10 plate is placed beneath and at a plate distance of 25 inches. The principal ray is made to fall between the lower border of the jaw and the upper border of the clavicle and directly over the thyroid. Thirty-five milliamperes with a 5-inch gap will give a very satisfactory radiograph in from ¾ to 1 second.

CHAPTER VI

TECHNIC FOR THE EXTREMITIES

Shaft.—The positions for plating the shaft of all the long bones, both upper and lower extremities, are anteroposterior, posteroanterior, and external and internal lateral, as well as stereoscopic, if desired. The technic va-

Fig. 31.—Position for patella.

ries for the different parts only in time of exposure. The plate must be brought into as close contact with the part as possible; the part fixed against movement, and the

central ray made to strike the plate at right angle to its plane and in line with the immediate point under examination. Using about 40 milliampères and a backup of 4 to 5 inches with the average distance of 18 inches, the time will vary from ¾ to 1 second.

Knee.—The knee from its anatomical construction of-

Fig. 32.—Position for lateral of knee.

fers three positions for plating to meet the requirements of the surgeon: the anteroposterior, the posteroanterior, and internal and external lateral, according to the seat of trauma or disease. This joint, similar to all others, also offers in addition to the above, the added advantage of the stereoscopic method, and, especially so, in pathologic conditions. Similar to all mobile structural parts of

pairs, the opposite or uninvolved knee should be radiographed for a control, when possible.

In radiographing the knee it is best to place the patient on the table and support the limb, if necessary, so as to give a complete relaxation to the muscles. For the delineation of the patella and arthritic involvement, the lateral internal and external posteroanterior positions are

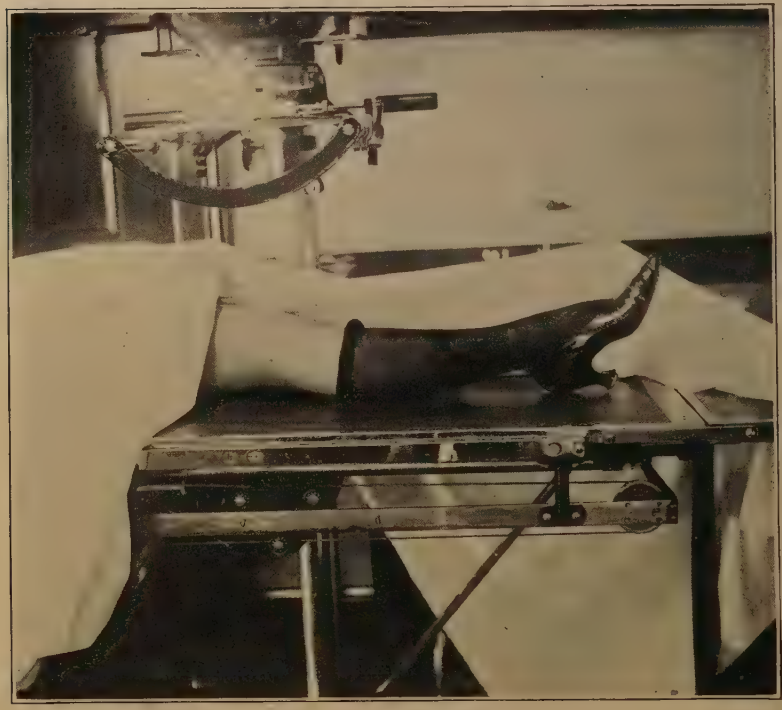

Fig. 33.—Anteroposterior position for knee.

the best, while for acute inflammatory involvement of the structural tissues of the knee, the anteroposterior and stereoscopic methods are to be selected as giving the best results. (Figs. 31, 32 and 33.)

Cone—8 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—25. Gap —4 in. Kilovolts—50. Plate—8 x 10. Time—3 sec.

Tibia and Fibula.—The positions for plating these bones are anteroposterior and lateral, and the size of the plate and exposure is in proportion to the field to be radiographed and the thickness of the part at the point of

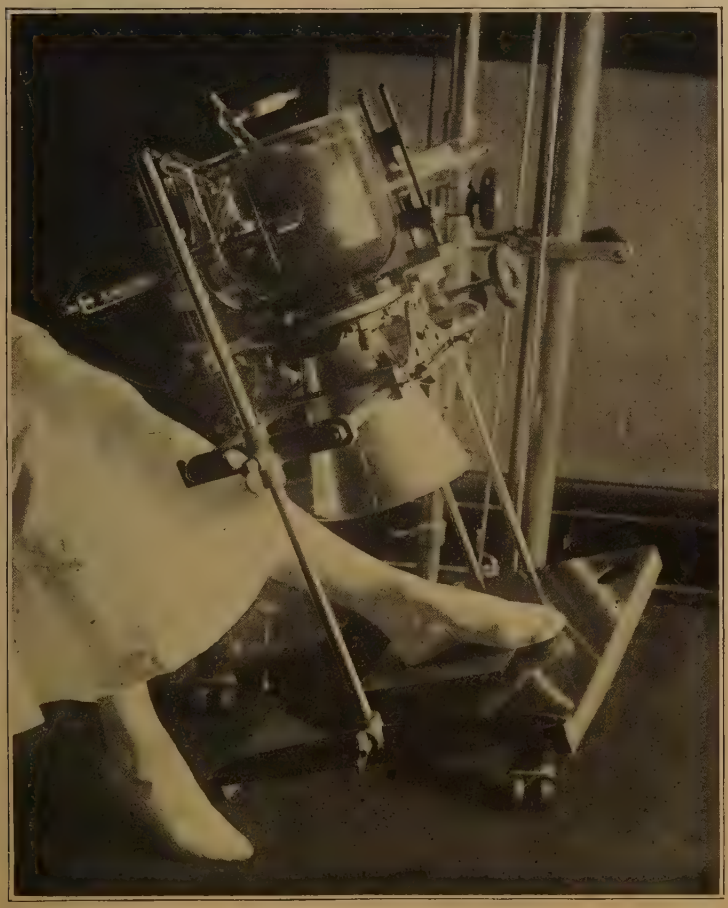

Fig. 34.—Anteroposterior ankle position.

exposure. The average distance for exposure is 18 inches, and, with a tube of above a 4 Benoist penetration, ¾ to 1 second is quite sufficient for a good skiagraph.

Ankle Joint.—A good definition of this joint can be obtained anteroposteriorly and laterally. The patient can be placed either on the table or in a chair, with the foot

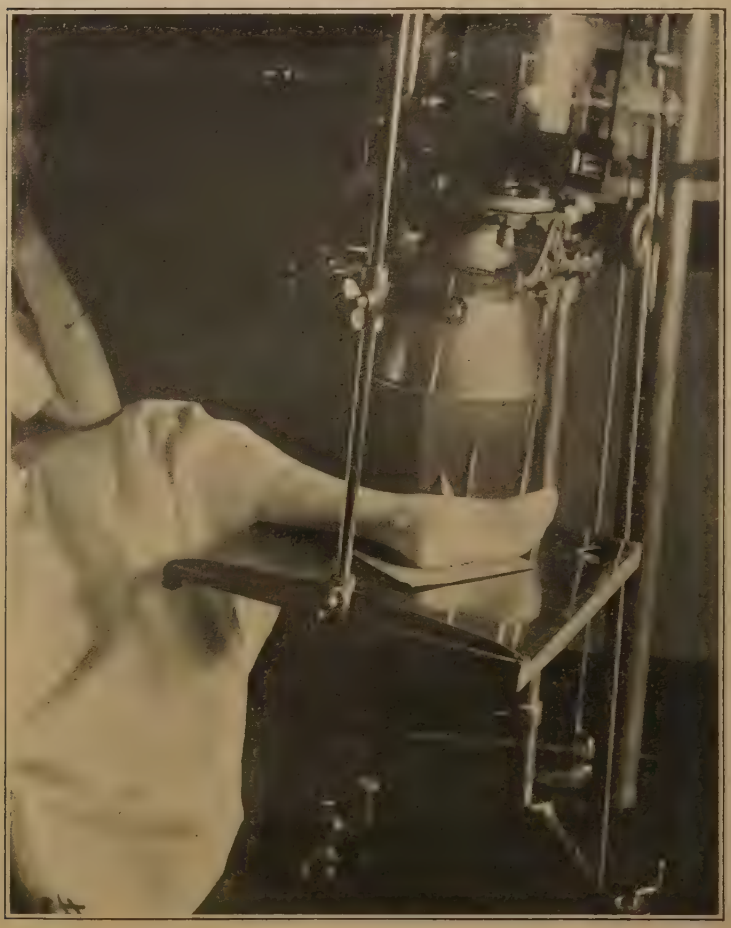

Fig. 35.—Lateral position for ankle.

supported on the platform of the tube stand or stool. The principal feature in the technic in radiographing this part is in obtaining as far as possible complete relaxatio· of the part and the centering of the principal ray over

or in line with the malleoli. It is advisable, as in the case of the knees, to radiograph both ankles where malformation is congenital, using the one as a control.

Cone—5 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—20. Gap—4 in. Kilovolts—50. Plate—8 x 10. Time—2 sec.

Feet.—Similar to the ankle the feet may be taken in a lying or sitting posture. In placing the subject, the part should be under no muscular strain. The central rays from a lateral position should be directed over the astragalus and for the anteroposterior view the principal rays should strike the astragalus, but with the tube tilted to an angle of about 45 degrees and in line with the astragalocalcanean articulation. On account of the different densities of the tarsal and phalanges two methods of equalization are at our disposal from an exposure standpoint. The one is known as the "building up" and the other as "the reduction." In the "building up," parchment or aluminum of varied thicknesses is applied over the metatarsals and phalanges during the exposure, while with "the reduction" method exposure is simply for the denser tissue. After development and washing, the part of the plate which was overexposed is reduced with a solution of potassium ferrocyanide. (See Darkroom Technic.)

It is advisable to radiograph both feet, using the one as a control.

Cone—5 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—20. Gap—4 in. Kilovolts—50. Plate—8 x 10. Time—1 to 2 sec.

Os Calcis.—It sometimes becomes necessary to demonstrate the posterior surface of the os calcis, and in order to do this the patient must be made to stand on a stool or table with the knee flexed in such a manner that the tube can be brought down to within 18 or 20 inches of

the plate which has previously been placed beneath the foot and tilted to an angle of about 45 degrees. This permits the central ray to strike the superior surface of the os calcis and in line with the malleoli. With 40 ma. and a backup of 4 inches, the time of exposure will approximate 2 seconds. (Fig. 36.)

Shoulder.—This part of the body offers a field for both trauma and disease, and is one of the most common to

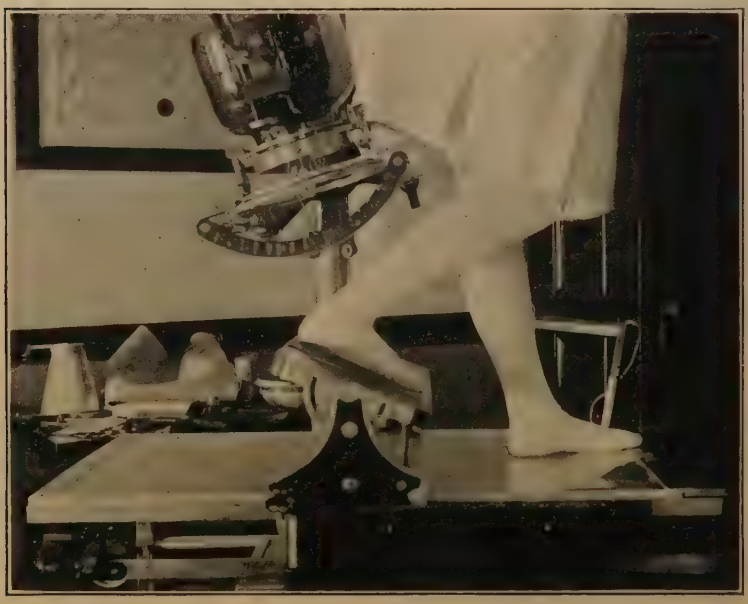

Fig. 36.—Position for os calcis.

come under the care of the roentgenologist for diagnosis. On account of the complexity of angles and its relation to the thorax, it cannot be radiographed satisfactorily other than stereoscopically. In order to do this successfully, it is necessary to place the subject on the back with the injured side resting full on the plate; and this can be accomplished by building up the opposite side with sand bags or fillers so that the shoulder to be plated will lie

flat to the surface of the plate. The arms are placed to the side of the patient and the central rays directed to fall one inch inside and slightly above the axilla. The necessary tilt and shift of the stereoscopic attachment is

Fig. 37.—Anteroposterior shoulder position.

made laterally for fracture of the humerus and clavicle, and the shift from a 45 degree angle for the glenoid cavity, coracoid process and spine and the scapula. (Fig. 37.)

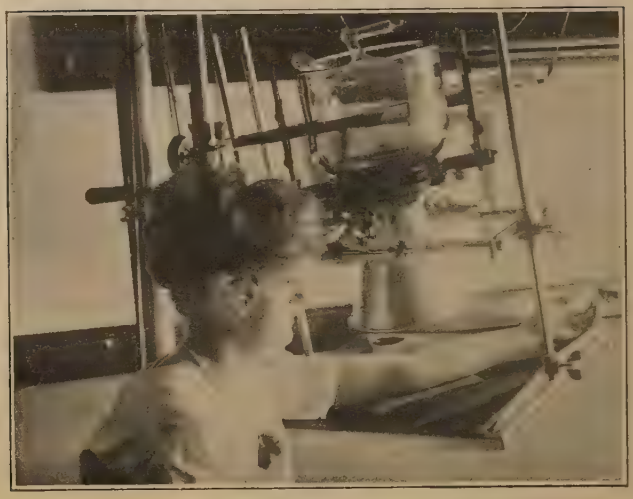

Fig. 38.—Anteroposterior elbow position.

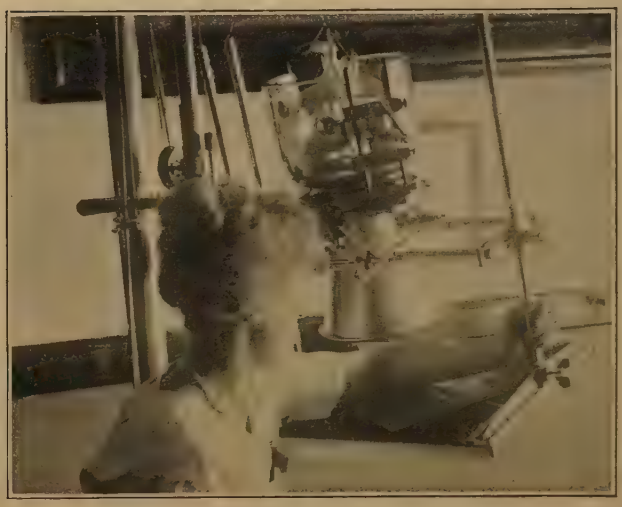

Fig. 39.—Position for lateral of elbow.

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—25. Gap—4 in. Kilovolts—50. Plate—8 x 10. Time—4 sec.

Elbow.—The anteroposterior, lateral and stereoscopic are the positions used in radiographing this part of the

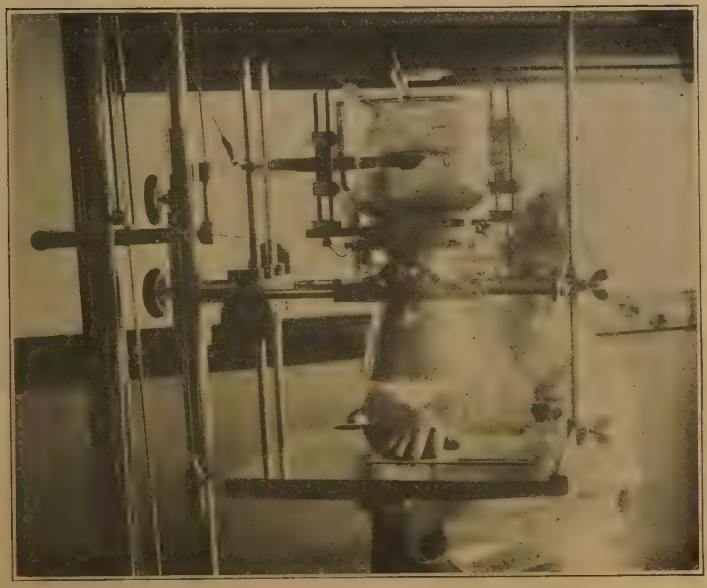

Fig. 40.—Anteroposterior hand and wrist position.

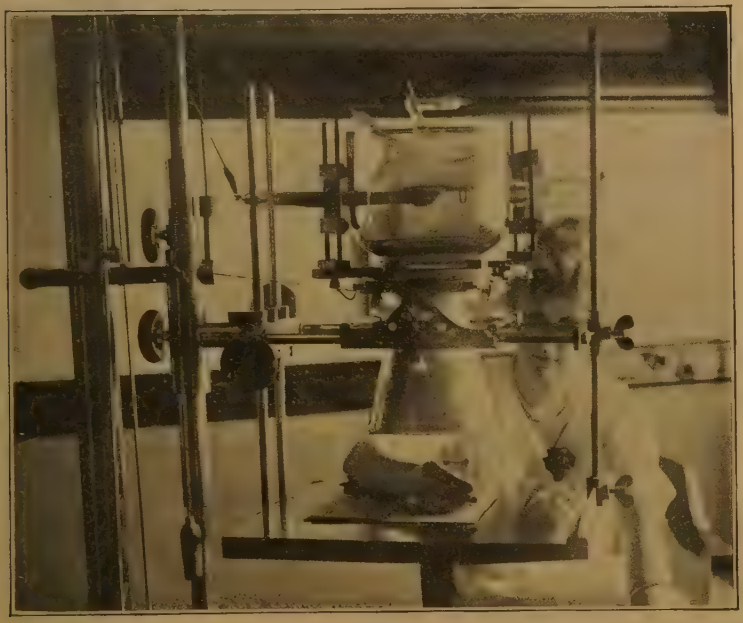

Fig. 41.—Lateral hand and wrist position.

body. In all positions the central rays are directed to fall in line with and between the condyles.

Cone—5 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—20. Gap——4 in. Kilovolts—50. Plate—10 x 12 divided. Time—4 sec.

Radius and Ulna.—Two positions offer themselves for plating the anteroposterior and lateral; and in every instance both positions should be plated. With the exception of the time and the necessity of centering the principal rays over the seat of injury, the technic as applied to the elbow will produce excellent results. Time on Seed's plates would approximate ½ to ¾ second.

Hand and Wrist.—The positions are anteroposterior and lateral, and for the carpals, stereoscopic. (Figs. 40 and 41.)

Cone—8 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—20. Gap—4 in. Kilovolts—50. Plate—8 x 10. Time—3 sec.

CHAPTER VII

ALIMENTARY CANAL

Radioscopy and radiography both play an important part in the examination and diagnosis of diseases of the digestive tract; this can only be accomplished through the medium of an opaque meal. Of the two, radioscopy is probably the more important, since by means of the fluorescent screen we obtain a better understanding of the function, peristaltic fluctuation, mobility, motility, etc., leaving to the radiograph the making of a permanent record for subsequent study and filing.

From the standpoint of the roentgenologist, the alimentary tract is divided into the esophagus, stomach, duodenum, jejunum, ileum, cecum, ascending, transverse and descending colon, sigmoid and rectum. The meal employed for the delineation is either in the form of a cachet, an emulsion, or mixed with cooked food. Probably the one most generally employed, especially outside the laboratory, and which is very satisfactory for all general purposes, is the barium sulphate suspended in fermilac in from 2 to 3 ounce quantities.

The following formulæ are here given as satisfactory opaque meals:

Barium sulphate .....2 1/2 ounces
Fermilac .....1/2 pint
Mix thoroughly and add 8 ounces of water.
Divide into equal parts before giving to patient.

Barium sulphate .....3 ounces
or
Bismuth carbonate .....4 ounces
Sugar of milk .....1 1/2 ounces
Water q. s. to make emulsion.
Take usual breakfast and follow two hours later with meal.

Barium sulphate .....2 ounces
Cream of wheat thoroughly cooked....12 ounces
Mix and eat with sugar and milk (not cream)
To be given on an empty stomach.

Barium sulphate .....5 ounces
Mucilage of acacia .....1 pint
Mix thoroughly and add
Water (temperature of 100 degrees) ....1 pint

Esophagus.—For the esophageal tracings the emulsion probably furnishes the best medium, especially in the tracing of diverticula.

Before undertaking the examination it is essential that the patient be prepared by the administration of a cathartic the evening previous, followed by an enema the next morning just prior to presenting himself for examination.

With the clothing removed from the field under observation, when practicable, the subject is made to stand with the back to the examining screen for a general radioscopic survey of the chest and abdomen; then from a right anterolateral position, with the slit of the diaphragm shutter vertical, the mediastinal and postcardial are inspected for growths, etc.

Now with the assumed position (right anterolateral), which gives a clear postcardial and free anterovertebral space, the patient, with the right arm drawn well back and to the side and with the left hand raised and holding a filled glass, the swallowing process is begun and the meal in the first receptacle disposed of. (Fig. 42.) Short swallows and then a continuous ingestion will give the most satisfactory visualizing definition of any abnormalities of the esophagus until it empties into the cardiac end of the stomach. If there is no obstruction, diverticula, etc., dark shadows will be seen to follow one another uninterrupted until the cardiac end is reached, where a normal delay is expected due to the natural nar-

rowing of the esophagus at that point. Any other delay or unusually long delay at the cardia must be investigated in order to determine the cause, whether stricture, foreign body or tumor. Any diverticula must be noted and a subsequent emulsion tracing made and plated. In making roentgenograms it is better to select the position

Fig. 42.—Position of operator and patient for esophageal tracing.

which during the screen examination shows the condition to the best advantage. For the oblique view the plate, taking the place of the screen, should have the same degree of obliquity. Lesions that have been definitely located are best plated by means of a small plate and small cone, since they show a better definition.

Modified Technic.—Before taking up the stomach and the usual technic employed, it might be well to mention the so-called modified technic or combination meal. Some operators prefer this in that it has the advantage of time, economy, and a more exhaustive study of the six hour retention. The principle is to mix 2 ounces of barium sulphate with 4 ounces of wheat cereal thoroughly cooked, to which milk and sugar have been added. This is given and the patient is told to return in six hours to the laboratory for examination. Then an additional 2 ounces of a watery mixture of barium for canalization is administered, subsequently adding an additional 10 ounces of a corn-starch pap, the examination being conducted as with the fermilac meal. However, for the average operator, and especially for the clinician who would trace his own cases, the simple fermilac meal will prove quite satisfactory.

Stomachs are different, roentgenologically and anatomically. The roentgen stomach is in reality more of an artefact, but since all roentgen stomachs are practically alike in this respect, it resolves itself into one of skiagraphic comparison and not one of anatomic accuracy.

Roentgenologically then there are two forms of stomach as to shape—the fish-hook and the steer-horn, so called from their respective shapes, and both are normal according to their habitus.

Stomach.—The patient now standing with his back to the screen stand and the whole of the meal ingested (which has been followed under a limited field of illumination for any filling defects), the entire field is put under general survey and the position, character, tone, size, etc., of the stomach noted.

The position of the organ is variable; while the size varies to a great extent according to the amount of contents, since the normal stomach is a potential cavity.

Mobility.—Seated comfortably in front of the patient with all the controls readily accessible, the question of mobility is next taken up and considered. This is detectable through deep respiration as well as the subsequent changes of position.

Flexibility.—Flexibility is an important characteristic of the normal stomach and is determined and the amount measured by palpation.

Air bubble.—A gas bubble, when in shape, characterizes a certain type of stomach; and the state of filling is of extreme value and should be noted from the first ingestion until the stomach has encased the full meal.

The Secretions.—Although not really in the field of the roentgenologist, the secretions can to a degree be determined by Sahli's capsules: the one "swimming" and the other "sinking," and both being opaque, permit measurement in a vertical field of the depth of the secretions. This method, however, is but relative, since the depth is influenced by the breadth of the stomach. In using Sahli's method the stomach must be free from other opaque substances.

Peristalsis.—Kinematography or bioroentgenography are the only true methods of plating the peristaltic movements of the digestive tract. If peristalsis is delayed, an effort should be made to stimulate it, and this is accomplished by pressure or massage. The result is but transitory and passes away quickly when the stimulus is removed.

Motility.—The motility is greatly influenced by the character of the meal as well as by the quantity ingested. Consequently, a standard should be established and deductions accordingly made. Barium leaves the stomach much earlier than bismuth, and liquids sooner than solids, and finally food taken after an opaque meal delays

the emptying of the stomach. Six hours is a safe limit for the normal stomach to evacuate.

Posterior Examination.—From the anteroposterior position the patient is now moved to the posteroanterior position for a survey of the posterior wall of the stomach, and after observing the size, position, motility, mobility, peristalsis, and any possible antiperistaltic wave, if present, the subject is placed *horizontally* on his back and the motility and mobility further observed as well as the position. By pressure on the fundus of the stomach the contents are made to pass into the duodenum, thereby delineating the so-called *bulb*, the sphincter, and the patency of the ring.

With the subject now turned to the right lateral decubitus, the duodenum is brought into better view and in conjunction with the jejunum and ileum in turn studied under pressure and manipulation.

Under ordinary circumstances, after tracing the head of the meal through the duodenum, the patient is permitted to leave with the instruction to return within four to six hours for further examination, when the meal should be low down in the ileum, cecum and ascending colon. During this interval of absence from the examining room, the patient should be instructed to eat nothing.

Duodenal Ulcer.—The technic for the determination and delineation of a duodenal ulcer is best taken up here before discussing the colon. It is as follows: With the patient on his back the stomach is manipulated so as to force the meal through the pylorus in sufficient quantity to fill the bulb. Then the subject should be rotated to one side or the other in order to bring the bulb into a better field for observation; at the same time relaxation of the sphincter by means of belladonna or bicarbonate of soda should be effected. By blocking the distal duo-

denum, the ulcer, if present, will be brought into relief, and the character and extent can readily be determined.

Serial Roentgenograms are not infrequently necessary in order to obtain a cycle record of the pyloric end of the stomach and duodenum, and in order to secure this end some appliance must be used which will permit of a ready change of plates without altering the position of the patient. A simple serial apparatus can be con-

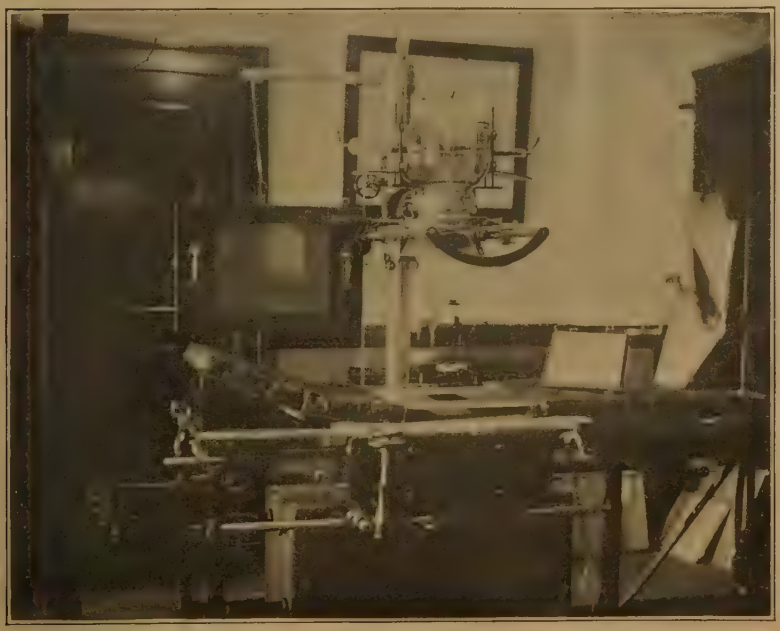

Fig. 43.—Simple device for taking serial roentgenograms.

structed for this purpose out of a piece of heavy sheet lead 15 x 17 inches, in the center of which a hole 4 x 5 inches is cut, and supported on a frame of wood sufficiently high to permit of free movements of an 8 x 10 casette beneath. (Fig. 43.)

The technic employed is to place the apparatus beneath the patient with the opening directly under the field to be plated. This is best accomplished by means of the

fluoroscope. A casette carrying an 8 x 10 plate is pushed under and to the upper left hand corner of the supporting frame, and an exposure made. From this position it is shifted to the upper right, then to the lower right, and finally to the lower left, a radiogram being made in each position. This shift and exposures can be made rapidly and the position of the part maintained. A serial will thus be secured which will be of considerable diagnostic value.

Colon.—There are two means available whereby we can trace this part of the digestive tract from a roentgenological standpoint: the ingested meal, where there is a suspected stenosis, and the injected clysma for a general delineation of kinks, etc. Ordinarily, six or eight hours after the ingested meal, the head of the column is in the ascending colon, and within twenty-four hours the transverse and descending colon, as well as the sigmoid and rectum, is filled. At the end of the six hours a sufficient meal is in the ascending colon to determine the competency of the ileocecal valve. Nevertheless, the clysma furnishes the most satisfactory means for this examination, and should in all suspected cases of ileocecal involvement be resorted to for a final and complete check up.

Injected Colon.—In preparing the subject for the injected meal, directions should be given to dispense with the evening meal and on retiring for the night to drain 1 or 2 ounces of castor oil. The following morning, after a reasonable breakfast, an enema should be given of warm water and the subject report for examination.

The enema is best prepared by mixing 5 ounces of barium sulphate with 16 ounces of mucilage of acacia (8 drams to the pint and filtered), and to this is added hot water (temperature 100 degrees) sufficient to make one quart. The patient, prepared by the removal of the

clothing from the pelvic portion of the body, is placed upon the table in such a manner as to permit of the placing of the plate for record subsequent to the filling and screening. A well lubricated tube, attached and drained of air bubbles, is inserted a short distance into the bowel and the light turned out. The fluid is now permitted slowly to flow into the bowel and the same is examined in detail under the screen; should any abnormalities present themselves, they should be plated immediately under a small cone following the completion of the injection. Probably ten to twenty minutes will be consumed in the filling. After a thorough examination of the filled bowel under the screen, the entire colon, as well as sectional parts, should be radiographed; the patient, removed from the table, is permitted to evacuate or the injection is syphoned off and the bowel again plated *in toto*.

There is another method used, which, however, has the disadvantage of a full appreciation of tone, flexibility and definite location of stenotic conditions. The modus operandi is that of filling the bowel from a high rectal tube, the same slowly withdrawn from the time the patient begins to feel the head of the meal in the right ileac region until the rectum is filled, and the same plated and screened and subsequently evacuated and again plated.

Small Intestines.—In most instances the small intestines can be studied in conjunction with the examination of the stomach, the subsequent examinations being made at such frequent intervals as suggest themselves to the operator. Visualization is best made in the standing posture, except for the lower coils of the ileum, which often lie behind the pubic arch; then it becomes necessary to place the patient on his back or in the right lateral decubitus.

Duodenum.—Beginning at the pyloric hiatus the duo-

denum sweeps upward and outward, then to the right and downward around the pancreas where it joins the jejunum. Therefore, it is necessary from a roentgenoscopic standpoint, to divide this part of the small bowel into three parts, *i. e.,* the pars superior, or so-called bulb, the descending part which is with difficulty seen, and the transverse part which terminates in the jejunum at the suspensory ligament of Treits.[3] The anteroposterior and oblique in a standing position will furnish the best definition of this part of the small intestine.

Jejunum.—Beginning at the duodenal juncture the jejunum courses toward the left hypochondrium, or downward and to the left. The first loops are often seen soon after the ingestion of the meal and are characteristic in their feathery appearance, due to the valvulæ conniventes. From the first course to the left the jejunum is not to be traced with any degree of definition or accuracy by any technic known at the present time.

Ileum.—From the jejunum the meal passes into the ileum and the valvulæ conniventes, and gradually disappears until the lower segment becomes quite clear.

The ileum is to be seen in midabdomen and right iliac fossa, and as previously stated should be examined in the standing posture except for the lower coils which may lie behind the pubic arch. The principal factor in the examination of the small bowel is the rate of evacuation, and this is influenced materially by the character of the ingesta as well as by the quantity, and whether the patient has been subjected to purgation and fasting, or not.

Intensifying Screens.—In the making of the record plates of the gastrointestinal tract it is advisable to use screens in order to diminish materially the time of exposure and to permit of an increased number of exposures if desired. The additional technic is based on the use of intensifying screens, on the average weight of the

subject, and in case the entire gastrointestinal tract is radiographed.

In ulcers in and about the pyloric end of the stomach it is advisable to plate your subject serially. Likewise, variations of technic, both screening and plating, can be, and will of necessity be, improvised to suit the circumstances of certain cases. The technic which has been given is solely an outline whose object is to furnish a working model applicable to the average case.

For plating use the following:

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—26 in. Milliamperage—30. Gap—5 in. Kilovolts—60. Plate—10 x 12 to 11 x 14. Time—¼ to ½ sec.

CHAPTER VIII

LIVER, GALL BLADDER, AND GENITOURINARY TRACT

Lesions of the gall bladder, except for an occasional defined stone and thickened or calcified walls, furnish a restricted field for the roentgenologist up to the present time. The liver, also, although not often referred to by the clinician, yields little except in certain malignant conditions or when altered in size and shape. Notwithstanding this, the liver must not be eliminated from the field of necessary technic, and this to be efficient must be scientifically accurate.

In preparing the patient for any abdominal examination it is essential to remove as far as possible the clothing covering the field under observation, and at the same time have the colon evacuated prior to the examination.

The subject thus prepared is placed on the table and screened vertically and horizontally before plating, which latter is best accomplished in the recumbent posture.

In radiographing the gall bladder, the patient should be placed face downward on the table and slightly rotated to the right, and here supported by the left arm and sand bags while the cone with attached drum is brought down under moderate pressure and tilted up and inward over the position of the gall bladder.

This and the following technic will give as much as is possible to delineate at the present time. (Fig. 44.)

Cone—8 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—compression. Milliamperage—35.

Gap—4 in. Kilovolts—50. Plate—8 x 10. Time—Double screens 2½ sec.

WITH BUCKY DIAPHRAGM

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—25. Gap—7 in. Kilovolts—80. Plate—10 x 12. Time—4 sec.

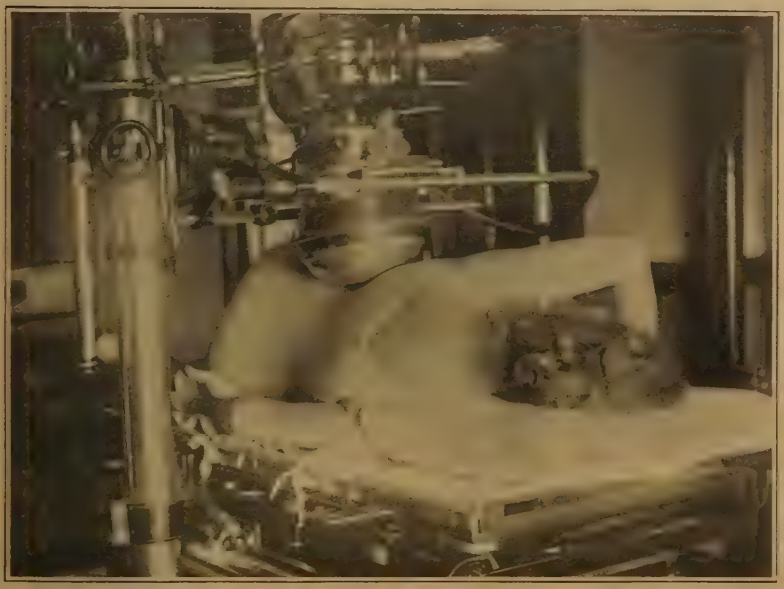

Fig. 44.—Gall bladder position. Plate shows patient rotated too much. Should be more on abdomen.

Urinary Tract.—Roentgenology now plays an important part in the diagnostic field of the genitourinary tract, and the conservative surgeon, prior to operation, refers every case of suspected stone for confirmation. A proper examination not only delineates the presence of the stone, but also its position, size and character, and at the same time suggests the manner of treatment.

Exclusive of the presence of a calculus, the most common urinary troubles which present themselves to the laboratory man are tumors, tuberculosis, congenital cysts,

etc.; these are diagnosticated to a more or less degree of accuracy, while nephroptosis, kinks, and impacted stone in the ureter are positive, especially if the contrast method or so-called pyelography is used.

In the bladder we get a more decided definition of calculi, and in such cases, in which it has been found advisable to resort to the special technic of injection, the walls are outlined beautifully along with the pelvis of the kidney, thereby showing in relief growths, malpositions, etc. The ordinary technic employed in the examination of this tract is first to prepare the subject by the administration of a cathartic the evening before and an enema one hour preceding the examination when time and conditions will permit. In the selection of a cathartic, castor oil or a vegetable eliminative is to be preferred, and the enema should consist either of soap and water or just plain water of 100° F. By using this preparation we exclude the possibility of the oversight of small calculi, especially of the ureters, and the elimination of fecaliths, etc.

The enema is not regarded by some as necessary, while others discountenance it on the grounds of gas-pocket formation: This, however, can be avoided if the enema is carefully given, or by allowing the tube to remain in the bowel for a time subsequent to the evacuation, thus permitting the escape of the accumulated gas. Then there are those cases in which a carthartic is counterindicated and the enema is the only resort; if given at least an hour before examination it will, in most cases, expel voluntarily all gas accumulation. Personally, I believe an enema, if properly given, is a valuable adjunct and should be adopted as a routine in the preparation of all kidney or urinary tract cases.

Position.—With the patient placed face downward on the examining table, the kidneys are subjected to an in-

dividual radioscopic survey under a small field of illumination; and then by means of a narrow vertical illumination the ureter alone and then in conjunction with the kidney and bladder is examined for stone, the kidneys having previously been visualized for differentiation of densities, mobility, and size. The patient is now placed on his back and the urinary tract plated as a

Fig. 45.—Position for ureters and kidneys.

whole (*i. e.*, both kidneys, ureters, and fundus of the bladder), or separately in the manner here described.

The following routine is suggested: The patient, prepared as before mentioned, is placed upon the back on the examining table, and the knee slightly elevated. An 8 x 10 plate is placed in the region of the kidney to be radiographed, with its lower border on a line with the

umbilicus. The tube with its cone is now brought down upon the abdomen midway between the umbilicus and ensiform cartilage and tilted about five degrees to the right or left of the median line according to the kidney under examination. From this position it is now tilted about 25 degrees to a point up and under the ribs and

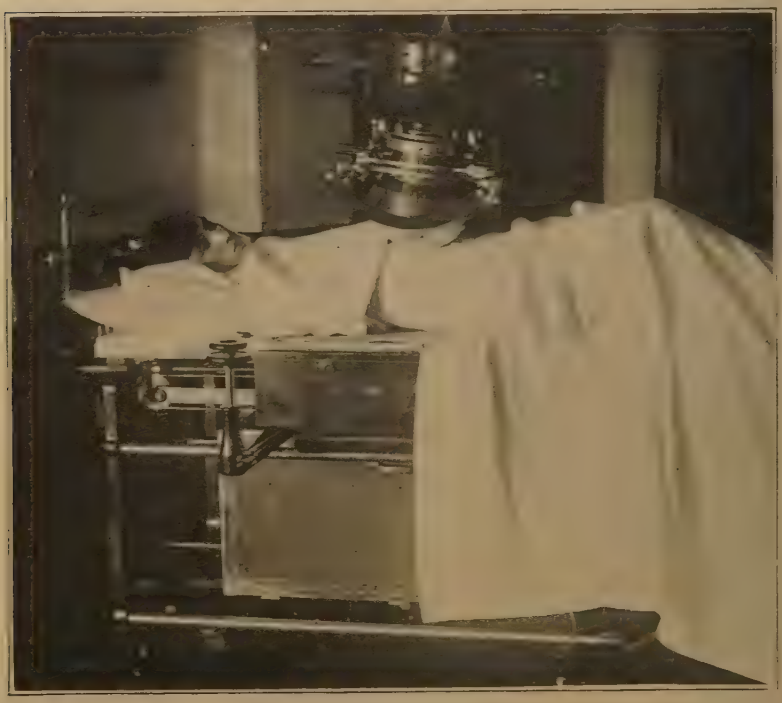

Fig. 46.—Kidney position.

pushed forward as far as the patient will stand without affecting his position, and here well fixed.

Try the patient on holding his breath and when satisfied with the results, make the exposure. This is very essential, as the kidney, being a movable organ, is readily influenced by abdominal movement, and the radiographic results are therefore naturally affected.

In all conditions, where practicable, the bladder should

be studied both anteroposteriorly and posteroanteriorly, and plated in like positions.

In order to make a record of both kidneys, it is necessary that a plate of sufficient size is employed so as to cover the entire field, including the upper ureter, and under compression with the tube tilted slightly upward in conformity with the abdominal wall and well up un-

Fig. 47.—Position for anterior surface of bladder.

der the ribs. The central rays are then made to fall about 1 inch below and in line with the umbilicus.

For the lower ureter and bladder the tilt is in the opposite direction to that for the kidney, and the principal rays should center about 3 inches above the symphysis pubis. For the anterior surface of the bladder the patient is placed face downward, and the tube is tilted up-

ward and the central rays are made to fall over the coccyx. This position also applies for the prostate. In making an examination of the urinary tract, always make the bladder examination first in order to eliminate concretions in the prostate.

Many operators prefer to plate their cases in sections and in this there is some advantage. It permits of a closer approximation to the field by reason of the smaller cone and the ability to get well up under the ribs, and at the same time a better compression of the superimposed tissues, but on the whole the one is in general quite as good technic as the other, and it is but a matter of choice. The additional technic, except for the size of the cylinder, is the same.

Cone—8 in. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—compression. Milliamperage—25. Gap—5 in. Kilovolts—60. Plate—8 x 10. Time—double screen 1½ sec.

With Bucky Diaphragm, entire genitourinary tract can be radiographed at one time.

Cone—none. Diaphragm—5 in. Filter—1 mm. of aluminum. Distance—25 in. Milliamperage—25. Gap—7 in. Kilovolts—80. Plate—11x14. Time—4 sec.

Pyeloroentgenography.—The patient is prepared as aforementioned and placed on the table over the cassette or plate changing tunnel (the latter to be preferred from the standpoint of convenience), and is here catheterized by the urologist or attending surgeon; about 10 to 15 c.c. of a selected solution is allowed to flow slowly in under its own weight. Upon the first evidence of distress to the patient, the flow must be stopped, otherwise damage may result. The cassette is now run into place if the tunnel is used and the radiogram is made. This technic will give a shadow of sufficient density and extent to demonstrate the pelvis and calices of the kidney, as well

as the ureter, permitting of the detection of nephrocystosis, kinks, and diverticula.

The solutions used are thorium in a 10 to 15 per cent, cargentos in a 20 per cent, and collargol in a 10 per cent solution. The one most commonly used in this country is thorium nitrate which is quite satisfactory. Bismuth emulsions should never be used, since they cannot be completely washed out and they may form a nucleus for calculi formation. Irrespective of what opaque salt is used, pyelography is not free from danger and should only be used when other means have failed. In cases where doubtful shadows are seen within or near the course of the ureter, an opaque catheter can be used with good results.

For bladder injection, probably a 2 per cent solution of iodide of silver to the quantity of one pint is the most satisfactory, and this, similar to the solutions for the ureters and kidney, must be made fresh just prior to use.

The additional technic is the same as already given for kidney, etc.

Pneumoperitoneum or Special Technic for Gall Bladder, Spleen, Uterus and Appendages

Somewhere back in the spring of 1902, Kelling conceived the idea of inflating the peritoneal cavity with air in order to lessen the resistance of the passage of the ray, and thereby permit of the study of certain abdominal organs.

Eight years later Jacobaeus, of Stockholm, revived the method, and published monographs on the subject of laparo- and thoracoscopy under air inflation. In January, 1912, Weber and von Bergmann, of Kiel, following some experiments with oxygen in the bladder, decided that sterile oxygen injected into the peritoneum would be of inestimable value in visualizing the liver, spleen,

etc., and increase the possibilities of diagnosis of abdominal tumors. Following these, came Lorey, Rautenberg, Meyer-Betz, Goetze, and Schmidt with their experiments and observations, until it can now be accepted as a practicable, valuable and justifiable procedure.

The technic is extremely simple: The intestinal tract must first be thoroughly cleansed, and the bladder emptied. With the patient upon his back, a point is selected on the anterior abdominal wall, about 1 inch to the right or left and 2 inches below the umbilicus; the skin is thoroughly cleansed over the selected area and painted with iodine; next, the skin is anesthetized with a spray of ethyl chloride and an ordinary lumbar puncture needle is passed obliquely downward until it reaches the fascia, and then gently pushed through the fascia, muscle, and peritoneum, into the abdominal cavity ; the plug is withdrawn and the needle is connected with a rubber tube attached to an ordinary oxygen tank.

The amount of gas to be used depends, to a great extent, upon the discomfort of the patient; however, only sufficient should be injected to give the abdomen a dome shape.

When this has been accomplished, the tube is disconnected and the needle quickly withdrawn, the site being covered with a small piece of adhesive plaster. Strict asepsis should be exercised throughout the entire procedure. Should the patient complain of pain and much discomfort from the distention, it is wise to administer a hypodermic of morphine, before proceeding.

The prone position is probably the best; however, this must be modified to meet the condition of the organs to be studied, remembering that the organs to be examined must be in the highest plane, in order that they may be surrounded by gas, and that the intestines, being fairly movable, will be pushed out of the way.

1. In general, it may be said that the position for the best illumination of the liver, diaphragm, and spleen, is that of the patient on his abdomen and stereographing from behind.

2. For the liver, spleen, and kidney: The patient should lie on the side and with support behind; the tube is then placed in front over the field to be radiographed.

3. For the uterus and appendages: There are two positions—namely, the right and left exaggerated lateral Trendelenburg. The patient is placed on the abdomen with the tube below and the table tilted at the foot, 10 to 20 degrees, thus forcing the intestines to drop forward and out of the pelvis.

4. On account of the discomfort incidental to the gas inflation, which lasts for some twenty-four hours, as well as for necessary asepsis, it is advisable that this examination be made at the hospital where the patient can be properly handled and subsequently cared for.

CHAPTER IX

STEREOSCOPY AND LOCALIZATION

Stereoscopic Roentgenograms.—These are most valuable in the proper delineation of the joints, chest, and many abdominal conditions and organs, and, to some extent, as a means of localization.

Stereoscopics are worked out on the basis of a binocular vision and are made as follows:

With the patient placed upon the table and the part to be radiographed placed over the center of the exposed part of the tunnel or the plate to be first exposed, the tube is so adjusted as to bring the central rays directly over the part under suspicion and the distance established. The tube is now tilted to such an angle that when moved 1¼ inches to either side of the center, the rays will be brought to the same focal point. This can be determined by means of a pointer, or can be worked out from the following scale:

17 inches, tilt 5 degrees
19 inches, tilt 4 degrees
21 inches, tilt 3 degrees
23 inches, tilt 2 1/2 degrees
25 or more inches, tilt 2 degrees

The first exposure is made to the right, 1½ inches, with the tilt in and to the proper degree, according to the height from the plate of the target. The plate is then shifted out of the way and another replaced, and the tube tilted and moved in the opposite direction the same given distance, and a second exposure made. These are developed and when dry are placed in the stereoscope for ex-

amination. The result will be a view which will permit of relative judgment of distance and parts, and where a skin marker has been used you obtain a relatively accurate picture for comparison and localization.

Localization.—The question of the exact localization of foreign bodies is difficult as well as vitally important, especially in military service and since the original of this chapter compilation has been materially enlarged by our own as well as foreign military service. I shall, however, give briefly such means and methods as were formerly used and which suffice for the average laboratory work of civil practice. For the extremities localization is comparatively simple, and if done immediately preceding an operation, is usually satisfactory, but for the cavities and especially for the head, it is rather complex and more vital as regards its exactness.

For the extremities the anteroposterior, lateral and stereoscopic views, well and accurately plated, or the simple fluoroscopic method, will suffice, while the method for the cavities resolves itself into one of mathematical precision; hence, various methods have been suggested, all of which have their virtues and their faults. Probably the one suggested by Mackenzie-Davidson, with its various modifications, furnishes the best means of truly locating, to a nicety, bodies imbedded or encased in the tissues of the various cavities.

In order to eliminate as far as possible the personal equation in localization, it is wise to resort to the several methods and in all cases not to eliminate the simple stereoscopic method, which is carried out exactly in the same manner as the ordinary stereoscopic technic, except for the addition of an opaque skin marker for subsequent comparison.

Cross-String Method.—This method of localization consists in taking a composite radiogram of a part and

making one's calculations from the junction of the angles.

The technic generally employed is to place the part to be studied as near under the central rays as possible, and placing the target over the plate, it is moved a given distance to the right and an exposure made. Without tilting the tube, moving the part or altering the position of the plate, the target is shifted the same distance to the left and a second exposure made. The shift from center and the distance of the target to the plate should be recorded. The plate, developed and dried, is placed over an illuminated stand and centered. The two needle pointers are adjusted to the respective points of the shadowed foreign body, and by means of thread and counter weights are carried up and over a cross bar already adjusted to the height of the target from the plate at the time of exposure, and are here crossed, to be fixed in a position corresponding to the shifts which were made to the right and left of the center during the radiographing of the part. From the point of intersection a perpendicular is dropped to the negative below and the distance from the cross wires measured by a pair of calipers. The point of intersection will now indicate the distance in inches or other units of measurement of the foreign body from the surface of the body that was in contact with the plate in a quadrant that is easily determined by reference to the distinguishing mark placed when taking the double exposure.

Fluoroscopic Localization.—There are various and sundry apparatus on the market for quick localization, some of which are good, while others are rather indifferent and unsatisfactory. Probably one of the simplest and, in many instances, quite a satisfactory method is by means of the fluoroscopic screen.

This is accomplished in the following manner. The

part is made stationary under the screen; with the diaphragm opening cut down to the smallest illumination practicable, the central rays are brought directly under the object sought and a mark made on the skin at that

Fig. 48.—Body and eye localizers.

point. It is then moved a given distance to the right and a similar distance to the left, and the skin is again marked at these respective points. The distance between these two outer markings furnishes one side of a triangle

and the known distance of the target from the screen the other side, the distance to the foreign body from the screen surface or uppermost part of the body under examination being computed by the formula as previously given (Figs. 47 and 48). Among other methods of consequence in use, are the Shenton with its circular diaphragm and metal pointer, the Hampson with the graduated scale, the cross-wire screen method, and the fluoroscopic method with the Hirtz compass. These are all in their way very satisfactory, but not altogether practical for work outside the laboratories.

Eye Localizer.—For the locating of foreign bodies in the eye I believe the Sweet-Bowen localizer offers the best and simplest means. A description of the practical application is here given in brief.

Two exposures are necessary in the production of a diagnostically correct plate. The apparatus consists of a supporting platform, a plate holder which accepts of a 5 x 7 plate, fixation clamps and a localizer. The plate is protected by a lead shield in such a manner as to permit of but one-half being exposed at a time.

With the patient lying on the table, the head, clamped to secure absolute fixation against movement, is placed with the affected eye downward as shown in the illustration (Fig. 49).

The diaphragmed tube is brought into position above in such a manner that the principal rays will fall parallel to the vertical plane of the front of the eye.

The localizer now placed on the stand is brought in line with the plane of the cornea, and, with the trigger set, is pushed up to and against the closed eyelid to the approximate thickness of the same, and the trigger sprung. Thus released it springs back exactly 10 millimeters and permits the patient to open the eye. The tube is now centered directly over the localizing ball; this

brings the shadows of the cone and ball in line on the plate.

In order to have a positive fixation of the eye, an object, such as a piece of paper or pencil, is placed in alignment with the site of the indicator and several feet away, and

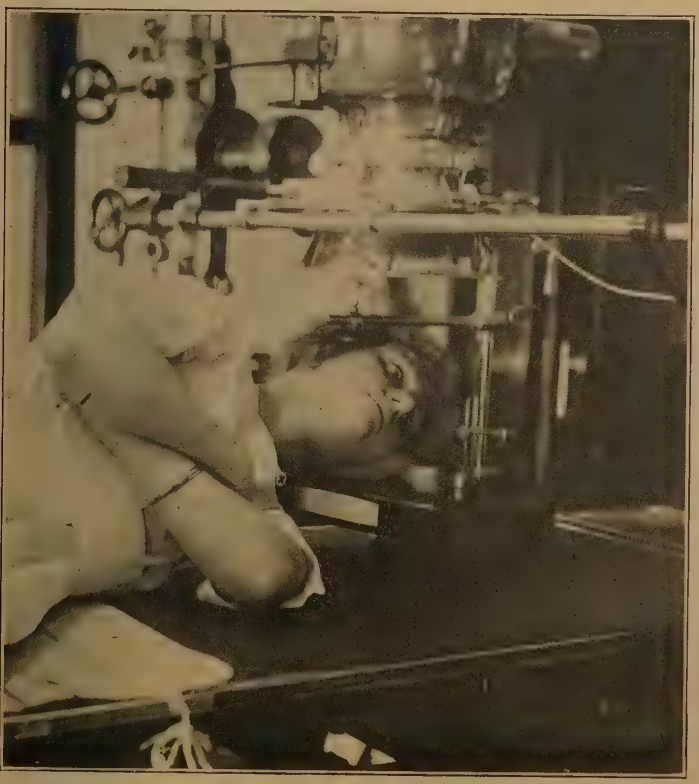

Fig. 49.—Relative position of table, patient and stand in use of Sweet Eye Localizer.

the patient is directed to look steadfastly at this while the exposure is made.

The plate is now pushed in to permit of an exposure of the other half and the tube shifted 4 or 5 inches toward the feet and tilted so that the indicator rod points to the ball of the localizer and a second exposure made.

With the plate exposed and developed one is now ready, when the plate is dry, to chart the findings.

The first negative will show the indicator ball and cone superimposed; by means of a pencil these are extended or projected into a line on the negative through the horizontal axis, thereby establishing the visual axis of the eye. A second line is drawn at right angle to the first and through the center of the shadow of the foreign body.

With a pair of dividers the distance is stepped from the edge of the indicator ball to the intersection of the lines drawn; then the distance is stepped off on the chart and dotted with a sharp pencil. The distance of the foreign body above or below the horizontal line is now measured, and the same on the chart above or below the axis is indicated.

The second exposure, which represents the oblique position, is next taken, and a line through the horizontal axis of both the ball and cone is drawn, thus establishing the relation of the horizontal plane to that of the foreign body. A third line is drawn through the foreign body and at right angle to the others. The distance above or below the horizontal plane of the ball is now measured, and the same is marked by dots on the front view of chart; a similar procedure is followed in its relation to the cone. A line now drawn through these two points will give the true course of the rays in the second exposure; the intersection with the projected line from the side view will be the position of the foreign body, when viewed from the front, while a vertical perpendicular through the horizontal section will show the position of the foreign body to the nasal or temporal side (Fig. 50).

On account of the possible variation from the normal size of the eye, it is advisable to have a checkup made by

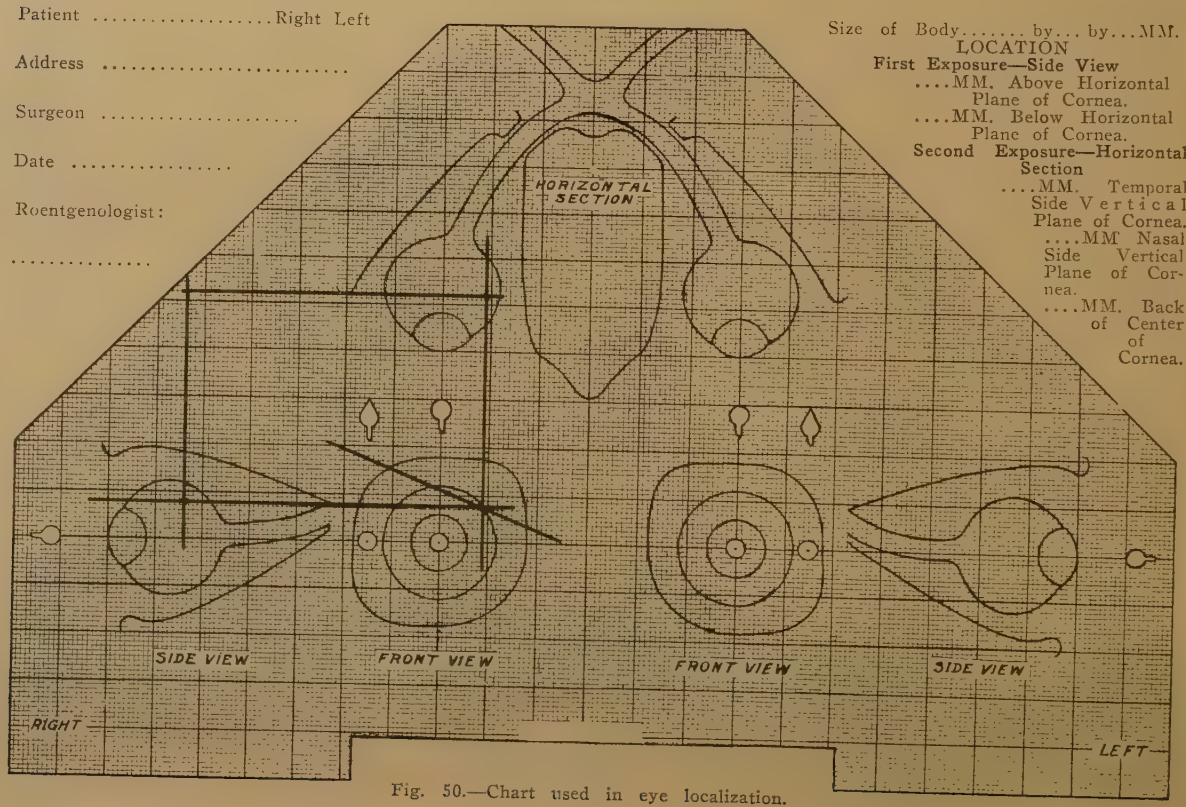

Fig. 50.—Chart used in eye localization.

means of the ophthalmoscope, and thereby make such correction as may be necessary.

Pelvimetry.—With the use of the Bucky diaphragm and double screens, pelvimetry is now practical, and of great value especially to the obstetrician. Various methods have been devised, all more or less complicated, and reasonably accurate. The best from a point of simplicity and accuracy, and wholly practical, is that suggested by Drs. Chamberlain and Newell of Stanford University.* The ordinary laboratory table and attached tube stand and trochoscope box is used and the patient is placed upon the back with the pelvis over the window across which is stretched a wire; at the same time a lead marker is placed under the right hip.

From a ring in the center of a 1 mm. aluminum filter is suspended by a cotton thread a plumb bob, consisting of a rod 3 x 30 mm. with two rods 1 x 30 mm. set through it at right angles to its long axis and to each other.

The tube is now brought down and centered over the right iliac region and an exposure made. From this position the tube is shifted 10 cm. to the left and parallel to the wire above mentioned, and a second film exposed. These films are enclosed in cassettes and brought into position in the stereoscopic plate carriage, without any change in the position of the patient.

A satisfactory exposure can be obtained by using a 7 in. backup; 20 milliamperes of current, and plate distance of 25 inches, in 7 seconds. The films when dry are placed in the stereoscope and the points marked between which measurements are desired. These points are the promontory and symphysis, the ischial spines, the brim of the sacroiliac joint, and the iliopectineal eminence. Now over one of the radiographs place a piece of celluloid and

*Pelvimetry by Means of Roentgen Ray, Am. Jour. Roentgenology, May, 1921.

mark two dashes over the shadow of the wire, the center of the plumb bob and the points on the pelvis, marking same for identification.

The celluloid is now removed and placed over the other negative, setting the dashes over the shadow of the wire

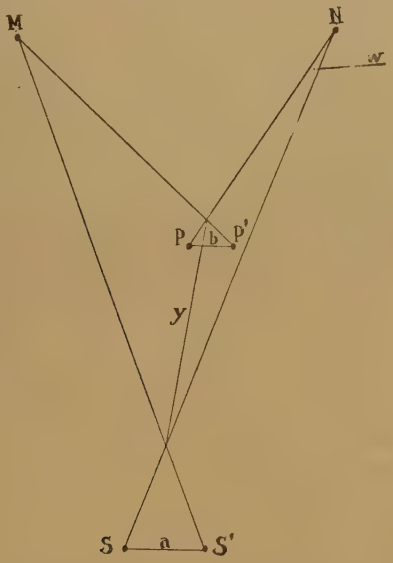

Fig. 51.—Tracing ready for measurement. *M* and *N* are the plumb-bob marks, *W* and *W* mark the wire, *P* and *P'* the promontory, and *S* and *S'* the symphysis.

and the mark for the plumb bob exactly 10 cm. from the second plumb bob shadow. The points on the pelvis are again marked in their new position. Draw lines connecting the plumb bob dots with the pelvis dots belonging

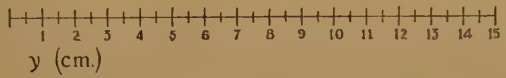

Fig. 52.—Special scale for measuring the tracing.

to each and others connecting the intersection. The tracings for measurements will then appear as illustrated in Fig. 51.

Using a centimeter scale the length of Y equals length of horizontal projection of the required diameter. The special scale (Fig. 52) laid on A and B gives the height in centimeters of each end of the conjugate above the plane of the film. The length of the conjugate is then computed from the formula $X = \sqrt{Y^2 + (a-b)^2}$

DENTAL AND ORAL RADIOGRAPHY

CHAPTER X

In taking up this branch of the work we are approaching one of the more recent demands made on the radiographer; and it is by no means a simple one as might at first be supposed. The very nature of the structures, as well as the complexity of the angles, requires care and judgment in the production of a satisfactory radiogram. One is not confronted with fixed positions as in other parts of the body, but with unknown angles, vertical and horizontal, no two of which are alike in the same or different patients, and with the added minute macroscopic detail of structure if the work is to be accepted by the careful dental surgeon as satisfactory. It would seem, therefore that an accurate knowledge and an anatomic appreciation of the oral cavity is of prime essentiality.

Among the methods at our command for the delineation of this part of the anatomy are the so-called extra- and intraoral; each has its special value.

Extraoral Method.—The technic for this method is not necessarily complex, but it must be accurate to insure definition and avoid undue distortions.

Probably the simplest and most accurate means of obtaining a radiogram of the dental field *en masse* is to place the patient on the table face downward, with the head supported on a sinus block base downward, and inclined forward and downward to an angle of 25 degrees and in firm contact with the plane of the plate (Fig. 53). The central rays are now directed to fall at a point between the angle of the inferior maxillary and the vertebral column and in line with the lower border of the

mandible. From this position a clear field of the opposite side is achieved without the interposition of structures opposite, which would render the negative of little value. A certain degree of distortion will take place, but it is of no great consequence, and is out of all proportion to the increased value of such a radiogram for diagnostic purposes.

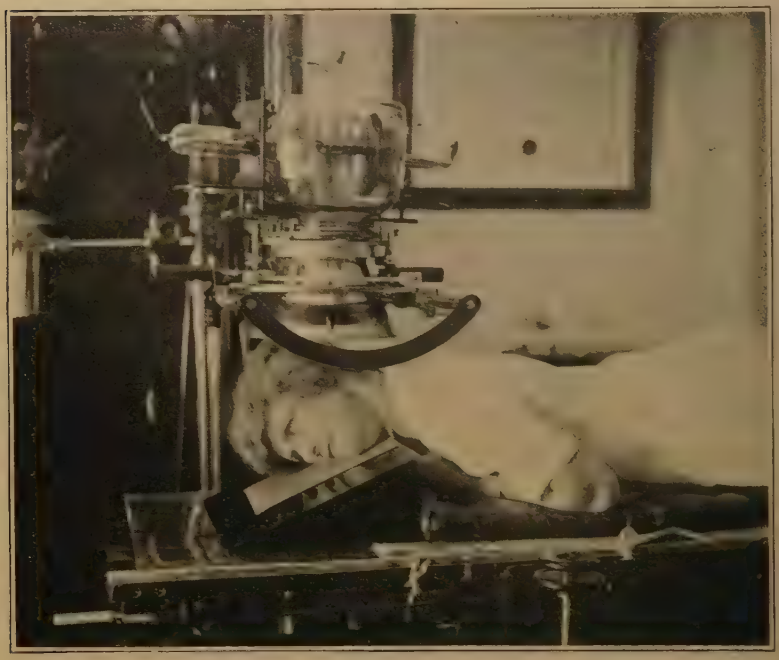

Fig. 53.—Position for extraoral position of teeth (laterals).

This position will give a good delineation of the right and left sides and, from the temperomaxillary articulation, to and including the cuspids. If this technic is disregarded, especially as regards the position of the central rays to the superimposed structures, a worthless skiagram will result and the dental surgeon will have but a confusion of shadows. It may be well to add here, as additional technic, the advisability in every instance and

in all positions of extraoral plating, of having the mouth closed and the teeth together in the natural occlusion.

For the central and lateral incisors the patient is placed as for the frontal sinus (anteroposterior) with the head supported and held firmly on a sinus block while the central rays are directed to fall at a point slightly

Fig. 54.—Position for extraoral position of teeth (centrals).

above and in line with the occipital protuberance (Fig. 54).

It is quite evident that in every instance this method will not constitute a thorough and complete examination, but that it will furnish an excellent working basis in cases to check up on by the more detailed intraoral method. In fact a complete radiographic examination is

only made when both methods have been resorted to and the checked findings correspond.

Intraoral Method.—This method, used for limited areas or as a checkup on fields obscure or developed by the extraoral, is rather complex and each case is a law unto itself. The anatomic construction and limited field materially increase the personal equation. Although there is the rule of "bisection of the angle made by the plane of the object and the plane of the film," yet it is but one of approximation, and moreover this variation

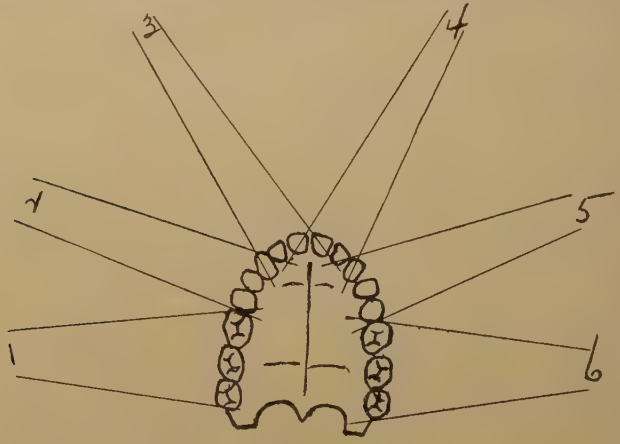

Fig. 55.—Diagram representing dental arches, showing necessary division in order to obtain sharp outlines of all the teeth.*

in the curvature of the dental arch will permit of but the delineation of one or two teeth clearly, especially those of the anterior arch.

In the intraoral method the small water proof enclosed film of celluloid is resorted to. This is placed in the mouth and held there, either by a film holder or, what is better, by the finger or thumb of the patient. This method is the one usually demanded of the laboratory by the dental surgeon, and is indicated when but small areas are to be radiographed; nevertheless, it is without value

*McCoy: Dental and Oral Radiography.

when there is an involvement outside the root and its immediate relations.

Before taking up the detail technic it is well to consider the dental arches from a division standpoint. This can be so bisected as to include the centrals or a lateral and central on the one plane. In the one method it will require twelve exposures to cover the entire field, while

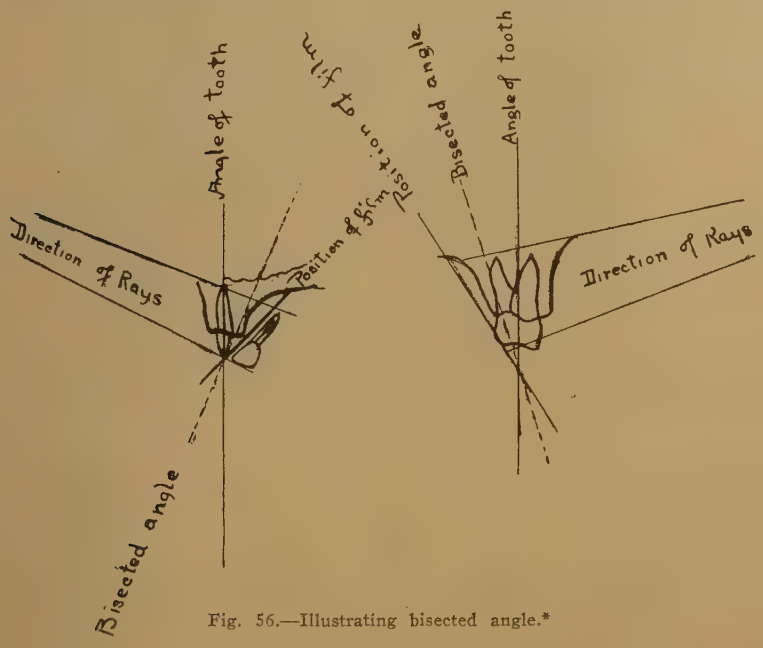

Fig. 56.—Illustrating bisected angle.*

in the other (both centrals) only ten exposures will be necessary, the governing element being the shape and angle of the anterior vault. Irrespective whether ten or twelve films are required to cover the field, it is imperative that each adjacent film position overlap its neighbor to such an extent as to leave no area not thoroughly delineated.

Three things are vital to intraoral radiography. Fail-

*McCoy: Dental and Oral Radiography.

ure to adhere strictly to the following rules will result in a partial or complete failure:

Rule 1.—Tube penetration must be in proportion to the distance, the density, and the exposure timed accordingly.

Rule 2.—With the head securely fixed against movement, the angle made by the plane of the object and the plane of the film should be bisected and the principal rays directed so that they will fall perpendicular to the bisected plane.

Rule 3.—Close approximation of the film to the teeth should be secured. This is best accomplished by the film being placed well up or down, as the case may be, to cover beyond the distal end of the root and there held in place by firm pressure of the thumb of the patient.

In the great majority of subjects the tilt from the vertical will approximate 10 to 15 degrees for the upper central and laterals, 20 degrees for the bicuspids, and 25 degrees for the molars, while for the lowers an angle of 90 degrees is necessary, except for the frontals, which must be plated at an angle of 10 to 15 degrees more. The foregoing is not given as an established rule, but as an approximation which, if used in conjunction with the accepted rules of angulation, will materially aid the operator and economize time.

The upper molars are by all means the most difficult to radiograph if we would obtain as comprehensive a film as the others. There are three views possible, and in some cases demanded—namely, a general picture in which the plane of the tooth lies between the buccal and lingual roots; a radiogram showing the buccal roots in exact length; and a skiagram showing the lingual roots in their correct proportion.

As for the incisors, which in some cases are quite as difficult to plate, and yet retain their exact length, we

have two methods differing only in the position of the film as held and the corresponding angle of the central rays. In those mouths in which we have a narrow, contracted anterior vault, it is advisable that the film be held

Fig. 57.—Position for upper centrals.

between the teeth, and that the central rays be directed from above and through the external nose. Otherwise the film can be placed, as in other positions of the upper teeth—namely, held firm against the teeth by the patient's finger and covering the arch and lingual side.

With the lower teeth these difficulties do not have to be overcome; with the exception of the frontals where the plane of the teeth and the plane of the film diverge from the parallel, the rays are directed at right angle. In the case of the frontals the principal rays are made to fall at

Fig. 58.—Position for upper molars.

a greater angle and centered over the point of the chin. There is one difficulty, however, in radiographing the teeth of the lower jaw and that lies in the placing and maintaining in position of the film. This is due to the fact that the tissues are usually quite sensitive; and, since

it is necessary that the film be pressed well down between the teeth and tongue, it is advisable to see that the corners are turned on the paper covering and that the film rests well down and fairly comfortable against the field under examination, otherwise distortion and indistinct, as well as incomplete, film negatives result, necessitating a retake.

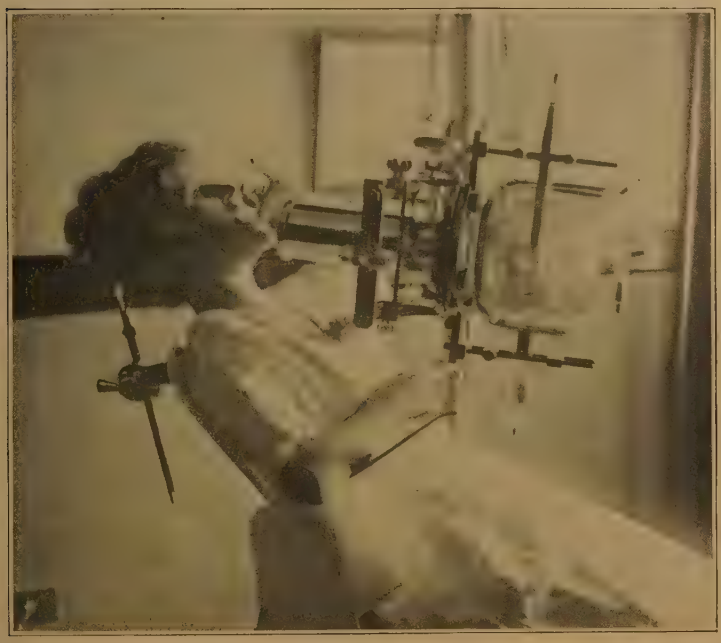

Fig. 59.—Position for lower centrals.

In general the technic for intraoral radiography is as follows: First of all, the patient should be placed on the table or, what is to be preferred, in a chair, and made reasonably comfortable. The head is fixed in a head support. This is imperative, since the slightest movement of the head will affect the efficiency of the negative. After the tube has been adjusted to the required vacuum, which should not be over a 4 Benoist in penetration, the

stand and cone are so adjusted as to cover the field under delineation and to the approximate angle as before given. The oral cavity is now surveyed under ordinary electric illumination (small pencil spot-light or transilluminating

Fig. 60.—Position for lower molars.

light, the film properly placed, and the angle of the bisection established. The central ray is now brought into the accurate plane and perpendicular to it, and the exposure made.

For the position of the patient, and the approximate angle see Figs. 57, 58, 59 and 60.

Submandibular Technic.—Whether calculi are the direct exciting cause or the result of infection involving the

Fig. 61.—Submandibular position.

floor of the mouth, the results are the same and the case comes to the laboratory for definition.

Calculi are most commonly found in the sublingual and submaxillary glands and ducts and are rather rare

in the parotids. In order to obtain a roentgenogram of this (sublingual) area, a large intraoral film is resorted to. This is placed between the teeth as far back in the mouth as possible, and the patient, with the head bent backward at an extreme angle, is here held while the central rays are directed to pass from the submandibular region as for the sphenoidal sinuses (Fig. 61).

There are two kinds of films for intraoral radiography, and these are classified, according to speed, as ordinary and extra fast. One is quite as satisfactory as the other, provided the exposure has been in accordance with the difference of speed.

For the operator using a powerful generator, the slow film will, in all probability, give the better result. However, this matters little, since an overexposed dental film can be readily reduced without altering the quality, and even then with the automatic timer, overexposure is unnecessary regardless of the speed of the film. The difference in the speed of the two makes of films is about one sixth.

It is well to remember that the emulsion side of the film is placed in contact with the smooth side of the oil paper or black side of the Buck's film, and that this side should be placed in contact with the teeth.

The following additional technic is given as a working formula and can be modified to suit environs and the wish of the operator.

Cone—3 in. Diaphragm—3 in. Filter—1 mm. of aluminum. Distance—20 in. Milliamperage—30. Gap—5 in. Kilovolts—60. Time—1 to 1½ sec.

Various devices have been put on the market for holding the film but none have proved satisfactory and the dental radiologists as a whole resort to the finger of the patient as a means of retaining the film in position during the exposure.

DEVELOPING ROOM APPLIANCES AND TECHNIC

CHAPTER XI

Only when the whole of a laboratory is under complete control can good work be expected; and the developing room is an essential of no mean measure. The efficiency, therefore, depends upon convenient and complete arrangements, as well as upon the exposure and other personal efforts. Hence, the developing room must of necessity be so arranged, especially if a large amount of work is to be handled, as to give the greatest efficiency with a minimum amount of unnecessary labor.

In placing the dark room it is well to have it in close proximity to the operating room and thoroughly protected from the effects of the ray. When possible, it should be lined with sheet lead for a height of 6 feet and provided with a double system of doors to facilitate entrance and exit without exposing the interior to the light. The room itself should be of sufficient size to permit of freedom of movement, and the ventilation and heating should be carefully attended to. Several lights of the ruby type are necessary, as well as white light exclusive of the wet-plate illuminating box.

The developing facilities should be arranged in one end of the room, when possible, allowing the other end for plate changing, etc. The developing stand should consist of a bench or table through which and to which are affixed tanks for washing and development (if tank developing is preferred), and a third for clearing solution. An additional wash tank is of advantage for the final washing. This will permit of the use of one tank solely for plates, which have not been subjected to the hypo

bath and which primarily should be dipped to insure the even flow of the developer when resorting to tray development. These tanks should be sufficiently large to accept of an 16 x 20 inch plate, either of enamel or soapstone, since iron and tin corrode from the action of the chemicals. Plenty of shelving is necessary and should be arranged so as to work to the best advantage of the operator. Drying racks should be placed in the developing part of the room to permit of the full play of breeze from an electric fan. As far as the color of the walls and stands is concerned, dark grey, green, or black is to be desired, since the eyes more readily accommodate to these colors.

Development.—The question of development is one of choice and experience. A correctly timed negative under proper conditions of development, fluid agents of a temperature of 65 to 70 degrees, and a standard formula for x-ray plates should be ready for clearing in from five to seven minutes. However, when doubt exists as to any of the requisites, it is best to develop in the open tray and stop when the desired density is reached. Personally, I prefer the tray method, since it brings the operation wholly under the control of the operator, and I only resort to the tank method as a matter of time, economy, or in an emergency.

Since so many elements enter into the production of a good radiogram, it is vitally essential that no carelessness is permitted to creep into any part of the operation of producing a diagnostically clear negative. Clean receptacles, accuracy in the mixing of the chemicals, and care in the handling of the plates, are as vital to success as the tube adjustment and timing.

The question of using a developer that has become discolored from use or age is a moot one and on the whole a dangerous one, since it will require a longer time for

development and, in consequence, an entire change in the manipulation with possible fogging and discoloration. It is best to throw out such a solution and make a new one, since so much is vital from a diagnostic standpoint in many instances and a true reading cannot be made from a poor negative.

The question of a developer is one of choice as well as of time necessity. For clear black and white of bone tissue, hydrochinon and an added amount of bromide will produce most pleasing results, while for the soft tissues, lung, cardiovascular, etc., as well as bone pathology, the addition of metol or elon and pyrogallic acid is essential. However, most any of the formulæ recommended by the several plate manufacturers, as applied to the x-ray plates, will give most satisfactory results in any and all character of work, provided the other conditions are right.

Appended herewith are certain formulæ which have proved most satisfactory with American-made plates when due allowance has been made for the difference in speed and thickness of coating. A plate or a developer should not be condemned until one has tested the temperature of the solution, and it is well to remember that certain agents, such as hydrochinon, will not act under 65° F. and will become unduly active over 70° F., with consequent results.

DEVELOPERS

Solution 1.—

A. Water .....1 gal.
Metol or Elon.....1/4 oz.
Hydrochinon.....4 oz.
Sodium sulphate .....7 1/2 oz.

B. Water.....1 gal.
Sodium sulphate .....7 1/2 oz.
Sodium carbonate .....10 oz.
Potassium carbonate .....5 oz.
Potassium bromide .....3/4 oz.

Dissolve and mix equal parts of solution A and B.

Solution 2.—

A. Water .....1 gal.
Hydrochinon .....6 oz.
Sodium sulphite .....4 oz.
Sulphuric acid .....4 dr.
Mix.

B. Water .....1 gal.
Sodium carbonate .....4 oz.
Potassium carbonate .....12 oz.
Potassium bromide .....8 dr.
Sodium Sulphite .....12 oz.
Mix and use equal parts of solution A and B.

Solution 3.—

A. Water .....1 gal.
Sodium sulphite .....24 oz.
Hydrochinon .. ..4 oz.
Edinol .. ..16 dr.
Potassium bromide .....24 dr.

B. Water .. ..1 gal.
Sodium carbonate .....28 oz.
Mix and use one part of A, one part B, and two parts of water.

It is not infrequent that we find that plates and films, especially dental films, have been overexposed and that after clearing in the hypo a state of density exists which does not permit of sufficient definition to warrant a proper diagnosis. To rectify this a reduction solution can be used to great advantage. In this we have the choice of the permanganate of potash or the ferrocyanide of potash. The latter, I believe to be the best. It is much more rapid and, if properly mixed and used, will leave a clean clear cut negative of value. The following formula is a good stock solution for this purpose:

Solution 1.—

A. Potassium ferrocyanide .....4 dr.
Water .. ..1 pint
B. Hyposulphite .. ..4 dr.
Water .. ..1 pint

Take equal parts of A and B, and after thoroughly washing the negative, dip same into the combined solutions, keeping it agitated during the re-

duction. It is advisable to mix only sufficient for use at the time, since it becomes inactive after a few hours.

Solution 2.—

A. Potassium permanganate .....6 1/2 dr.
Water .. ..1 pint

B. Acid Sulphuric .....6 1/2 dr.
Water .. ..1 pint

For use take one ounce of solution A, 2 drams of solution B and 8 ounces of water. When the negative has been reduced to the proper degree of density, it should be placed in a solution of plain hypo to remove yellow stains and then washed for half an hour.

Not infrequently it also happens that negatives are undertimed and require strengthening. This can be done to a certain degree of satisfaction by soaking the negative in the following solution after fixing and washing thoroughly.

Solution 1.—

Mercuric chloride .....120 gr.
Potassium bromide .....120 gr.
Water .. .. 12 oz.

When the image is white throughout remove and rinse in water and place in a solution of sulphite of soda, 1 to 8. The darkening action takes place slowly and steadily. Wash finally to free the plate of the sulphite.

Fixing or Clearing.—The question of the so-called fixing or clearing bath is quite as important as the development, and the solutions should be as carefully prepared either by weight or the hydrometer test. The following as a suggestion and as advocated by the plate manufacturers, will be found most satisfactory:

Hyposulphite of soda .....16 oz.
Water .. ..64 oz.

To this when fully dissolved add the following hardening solution:

Soda sulphite .....1 oz.
Acetic acid .....3 oz.
Powdered alum .....1 oz.
Water .. ..5 oz.

or

Plain fixing bath of hyposulphite of soda of a hydrometer test of 70.

In the course of one's work, one is frequently confronted with conditions of the plates which greatly puzzle for a time, and then one is at a loss to know the reason for the same and is tempted straightway to lay the blame on the plate and its manufacturer. There is but one real way out of this dilemma and that is carefully to check up the proceedings. A plate should never be condemned until all other things have been eliminated, for, as a rule, the plates as furnished now, if fresh, are seldom to blame and the fault is usually the operator's.

The tube vacuum, the time, the temperature of the developing fluids, the developer from a possible contamination, cleanliness of receptacles, water, dust, etc., should receive earnest consideration, and if then a definite solution of the trouble has not been reached, the plate manufacturer should be consulted.

The following hints, as taken from a publication of the Eastman Kodak Company, are worthy of mention here, since they will serve in many instances to solve troubles.

Testing Dark Room for Lights.—If there is any doubt regarding the safety of the developing light, this can be easily tested. Put a plate in a holder in the dark and expose half to the light for five minutes and develop in an absolutely dark room. If the exposed half of the plate is perfectly clear and shows no fog the dark-room light may be considered safe.

Streaks of light from imperfect chalking of the room will produce dark lines of varying degrees and these should at once be considered.

Fog.—A uniform blackening of the plate during development is due to fog. There are various kinds of fog and many ways in which it can be produced: Unsafe dark-room light, actinic light from an outside source, and chemical, either from too much alkali or too warm a solution. This can be remedied by the removal of the cause.

Reversal.—The reversal of light values, changing of a negative to a positive during the process of development, is most commonly caused by the exposure of the plate to an unsafe light after development has begun. Reversal only occurs after fogging during development, while fogging previous to the development merely blackens the plate.

Overexposure.—This produces lack of contrast. Likewise, too long a development will cause negatives to lose contrast.

Underexposure.—In an underexposed plate there is no detail, and if the development is carried too far, the high lights will become chalky.

Flat Negatives.—Thin and weak negatives may be due to underexposure, the developer used at too low a temperature, or on account of being improperly mixed and too old. Thin flat negatives are also due to insufficient development.

Frilling and Softening of Film.—This is due to using the developer and other fluids at too high a temperature. Violent changes in temperature of the various fluids is liable to cause frilling. Do not wash for too long a time and dry as quickly as possible, preferably with an electric fan. Negatives dry slowly in a warm, close atmosphere and with a tendency to increase density, and sometimes cause the emulsion to run.

Granular Indentations on the Film.—This is due to slow drying. The gelatin swells and separates, causing transparent blotches.

Mottled and Wrinkled Films.—These are another kind of frilling and are due to prolonged development. Too high a temperature is also to blame for this.

Blisters.—A very common cause of blisters is due to not thoroughly washing the plates after removal from the developer and before placing in the clearing bath. The alkali of the retained developer causes blisters through effervescence.

Stains.—Negatives may be stained from a variety of causes. Brown or yellow stains are usually due to decomposed hypo or imperfect fixing. Decomposed hypo will also produce discoloration, and the imperfect washing before placing in the clearing solution will permit of an insoluble salt of silver being formed which carries with it the irridescent stain.

Transparent Spots.—These are usually due to oily substances on the surface which repel the action of the developer.

Transparent Spots and Pitted Emulsion.—These are due to the decomposition of the film, the result of slow drying in a close-heated atmosphere.

Opaque Spots with Transparent Tails.—These are due to dust on the plate and fogging caused by reflected light.

Purplish Black Spots.—These are due to particles of iron from the supply pipe settling on the surface of the plate.

Opaque Streaks.—These may be produced by friction. They also may be caused by insufficient dusting of the plate, or by contaminated cotton or brush.

Numerous Parallel Vertical Lines.— These are produced by using decomposed pyro or a pyro combination developer and old fixing bath. This same condition will develop from contaminated reduction fluids of the ferrocyanide type.

Development by the Tray Method.—It must be remembered that a perfectly developed negative can often be obtained at 65 degrees, while the same plate would yield an underdevelopment at 60 degrees and a distinct overdevelopment at 70 degrees under the same number of minutes' development. Uncertainty of temperature means uncertainty of judgment, and in most instances a failure in results. The use of restrainers and accelerators must therefore be in accordance with the knowledge of the working temperature of the fluids and should be added at the beginning of development and not during the process if you wish the proper degree of contrast and to prevent having a fog. Tray development, therefore, has its advantage over the tank in that it permits of a personal element.

Tank Development.—This has not proved wholly satisfactory for roentgenologic work.

Protection of Plates.—The matter of plate protection is of vital moment. There is but one means of positive safety and that is a box heavily lined with sheet lead. This box should be of sufficient size to accept of the largest plates used in the laboratory and lined with not less than 1/16 inch sheet lead which has been thoroughly soldered at all the points. The plates are best to stand on end and the box should be built accordingly. It is well to have two such boxes, one for stock which is kept in the developing room, and the other for the operating room wherein are kept the plates filled in holders for immediate use.

Intensifying Screens.—These should never be kept in the developing room and should be removed from the cassette immediately after use and placed in some part not subjected to the fumes of any chemicals.

Reproduction on Paper or Plate.—The question of prints and lantern slides is one of individual preference

but is hardly to be considered as part of the technic of radiography. The production of prints, as well as the making of lantern slides, is simple, but requires additional equipment and consumes time, and from a point of economy of both time and money I would suggest that this work be referred to the professional photographer who makes a specialty of this type of work.

Plate Record and Filing.—A record either simple or exhaustive is a necessity. The plate is the property of the laboratory and to know your plate you must have not only a record of its disposition, but one of the making. Duplication is a necessity in many cases, especially those under treatment. In order, therefore, to make a true interpretation of the plates from a point of comparison, the taking and making must correspond, and to accomplish this a record must be kept of the character of the tube, the backup, milliampèrage, distance, and time.

Irrespective of efficiency, methodization is the one field of safety, and under the existing public prejudice one cannot be too careful, since not infrequently the record and plate are one's only protection.

Every careful operator has some system of filing records best adapted to his requirements. Some file and index plates under the name of the physician referring the case; others according to the serial number irrespective of the physician; and others still according to the diagnosis. Where one's clerical force will permit, I believe that from the standpoint of efficiency, convenience, and vital interest, the system of numbering serially, irrespective of the source or character, and filing the same under the name of the patient and in sections allotted to the referring physician, and then cross indexing them as to character, position, and diagnosis, is the best. In this one not only has an interesting compilation of facts for

comparison and statistics, but readily accessible files to draw from for any requirement.

One more word by way of suggestion; one's plate file should be kept under lock and key; likewise, barium sulphate should be separated from all other chemicals and locked up when not in use. This will be the means of saving some anxious moments.

Legal Right of the Roentgenologist*

The subpoena duces tecum is a hardship to the roentgenologist unless it is specified at the time of the laboratory examination that if called upon to appear in court with his radiographs he is to be remunerated as a specialist. Most States hold that a roentgenologist need not testify unless he receives the compensation due an expert, and he may take his case before the justice and be qualified. If this view is held clear in mind it will save many embarrassing situations and much time and money.

*See Legal Rights of the Roentgenologist for a Witness, By Joseph Friedman, M. D., (Amer. Jour. Roentgenol.), September, 1919.

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